THE JOURNAL OF ENGINEERING EDUCATION

VOLUME 34 NUMBER 10

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Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the Society for the Promotion of Engineering Education under the Supervision of the Publication Committee: H. T. Heald, Robert E. Doherty, F. L. Bishop, Editor, University of Pittsburgh. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the Act of August 12, 1912. Subscription Price, $3.00 per year; Single Copies, 50 cents.

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To the Editor

The editorial by Professor Gilkey in the March issue of the JOURNAL raises two rather important questions. These are presented below, accompanied by a brief discussion of each.

1. Is the basic difference between engineering and the other professions due to "performing purely personal services at a common level of professional stratification," or is it due to the attitude of each profession with respect to its sphere of influence?

I am no great admirer of certain features of the medical profession, but there is a certain practicalness in its educational and professional policy that seems to keep the profession's feet on the ground. The editorial, for example, points out that in order "to be at all comparable in scope to engineering, medicine would have to embrace everything from the delivery of a baby to the disposal of a carcass, from the manufacture of drugs and instruments to the performance of a tonsillectomy on a giraffe." * A member of a medical group, concerned with educational policies and viewing the formulation of these policies as we have done in engineering, would say that the medical profession actually did embrace the entire range of functions stated. If necessary, he would go on to point out that the medical profession with its background of ministering to human beings was well qualified to include such related fields. Furthermore, he would add, why not include "internes, nurses, attendants, medical technicians, nutritionists, ambulance drivers, pharmacists, druggists, chemists, bacteriologists, and veterinarians" within a *much larger enveloping group* which could be called the *medical fraternity?* Obviously, the *medical profession,* he would say, could not isolate itself from such a complex of personnel and functions into a well-defined caste. It could only exist as a *vaguely bounded nucleus* within the larger enveloping group. Furthermore, he could foresee, with such a comprehensive inclusion of functions, that the growth of the medical schools would be phenomenal (with budgets and staff reluctantly tagging behind, of course). Having tasted of these fruits, he would be able to see that the *broad* and *comprehensive* knowledge of *human beings* attained by medical practitioners would qualify the medical profession for the fields of management, economics, and finance. Medical schools would then be confronted with intriguing problems concerning the reduction or omission of basic medical courses in order to include "medical geopolitics—2 hrs., twice weekly," or "global mediconomics—1 hr. lec., 3 hr. lab., weekly." An additional development, not obvious at first but ignored later, would be that the broad and *comprehensive knowledge* of human beings, that was to prove so valuable in the newer fields, would no longer be attained by an individual specializing in the *advanced* work because he no longer had time for the practical experience in the field of medicine. The medical profession would then fail to develop

* Does a giraffe have tonsils?

the qualities desired in their professional men. All this, however, would raise the level of ability of the medical practitioner, no doubt.

2. Are we being "virtually forced into the fields of finance, management, economics, and politics" or are we permitting ourselves to be forced, and rather enthusiastically enjoying it?

If there has been any marked struggle, it has been well disguised. We have never provided our groups, formed to develop and guide basic policies, with specific regulatory powers. It is difficult to see any marked advancement possible unless such groups are provided with "delegated authority."

In closing, I wish to add that it is not the intention of this discussion to criticize the viewpoint or policy of the editorial, but rather to point out a fallacy.

GEORGE C. ERNST,
May 4, 1944

Author Comment

ON THE GEORGE C. ERNST DISCUSSION OF GILKEY EDITORIAL
(JOURNAL, March 1944, P. 445)

Professor Ernst brings out a number of stimulating thought-provoking aspects of this many faceted problem and with some of them I find myself in rather close accord.

While, in spite of the graphic case made, I still contend, assertively, that the middle-of-the-road professional ramifications of engineering greatly exceed in scope, variety and complexity anything possible in the field of medicine, I readily concede that we could conceivably have simplified our organizational problem had we adopted years ago some closely cropped definitional procedure akin to that employed by the medical profession.

Be that as it may, I fail to see how any such restrictive definition of Professional Engineer would now be possible without a major operation equivalent to the extraction of a heart or the amputation of a head. No matter whose fault it may have been (and we might as well accept it as our own), we are dealing with the "fraternity" rather than the "profession" and are confronted by the necessity of finding a common denominator for a large unwieldy and highly diversified group. If we propose to tackle this problem as the engineer is supposed to tackle any problem, we will accept the facts as we find them and build from here on out. The trend seems clearly to be toward even greater diversification of engineering functions rather than less; it is now too late for the clippers; a hairnet appears to be the only tonsorial unifying device at hand; an overall cover capable of embracing the entire engineering body—the fraternity.

In his quip-like reference to "medical geopolitics" and to "global mediconomics" Professor Ernst shows himself to be something of a curricular fundamentalist; one of those rather out of date individuals, of which there are still a few at large, who believe that an engineering curriculum should consist largely of basic engineering work. I too confess myself to be one of those queer personages;

not that there is opposition either to the knick knacks of attempted over-specialization in the undergraduate area, on the one hand, or to the cambric tea of the humanities, on the other, for they are admittedly non-toxic and devoid of neither vitamins nor nutriment. The objection to these curricular embellishments is not for what they are but rather for what they displace. In spite of much cultural clamor, I still believe that a curriculum rich in sturdy basic engineering content constitutes the best seed bed yet devised for the growth of professional culture and breadth of interest and outlook as well as for the technical engineering proficiency prerequisite to solid progress; that the ripened fruits of experience and maturity just aren't found dangling from the boughs or the brows of college-bred saplings, regardless of curricular soil. As we dilute and dissipate engineering substance in attempting to teach culture, judgment, maturity and life, out of books, I fear that we are only substituting a wash drawing of yearnings for the blueprint of an engineering career.

Returning to the central theme, the engineering fraternity is and will probably continue to be a sprawling affair, one presenting a difficult, but I trust by no means a hopeless, organizational problem. If we are to approach the problem rationally, it must be studied from such different angles as will promote broad over-all understanding. Professor Ernst's discussion constitutes a valid and valuable contribution.

H. J. GILKEY,
Ames, Iowa, May 13, 1944

Implementing the Report of the Committee on Engineering Education After the War*

By N. W. DOUGHERTY

Dean of Engineering, the University of Tennessee

Engineers believe in making study of what they are doing. Shortly after the last war we had the Mann report published by the Carnegie Foundation. The ink had hardly become dry before we started the investigation which lasted from 1923 to 1929. Both reports deserve very careful study today because they show many of the things the engineering colleges are doing now. There have been few major changes since the report of 1930 was published.

In 1939 Dr. Jackson completed his study of Trends in Engineering Education as gleaned from the reports of the E.C.P.D. visitation committees. This report was an excellent contribution to our knowledge of the work of the engineering colleges. In 1940 the S.P.E.E. Committee on Aims and Scope of Engineering Curricula made one of the best statements of our problem to date. Now we have a restatement of the 1940 report with some needed additions. You have heard the report. It is my task to discuss the implementation.

With the sign posts that have been erected along the way of engineering education, few of us should go astray. The Committee, however, asks us to increase our study of the problems before us. Within the body of the report there are stated many general principles. We need some one to fill in the details of the problem. The general direction is well known; now we must avoid the detours.

The present Committee report indicates certain trends in engineering education. A large number of students are applying the engineering method to the management and operation of industry. For twenty-five years this movement has been gaining headway as is shown by the number of colleges which have established courses in industrial engineering and a larger number which have added some specialization in management in the standard curricula.

Over against the management trend has been a demand for more scientific work on a creative level. As technology has grown in subject matter, graduate work has increased throughout the land. Industry is absorbing a larger number of graduates who have had advanced training in the several engineering specialties.

Educational Truisms

Before we discuss the Committee report, let us consider a few truisms in the learning process. A number of years ago Henry Van Dyke made a

* Presented at the meeting of the Southeastern Section, Georgia School of Technology, April 29, 1944.

statement that "memory is a capricious and arbitrary creature." This has been known a number of years yet we undertake to give instruction as if a student will remember all he reads and certainly all we say. We are much disturbed about the overlap in course content which exists in many of our programs. We should not be disturbed if the overlap presents subject matter from another point of view. Skills and concepts one develops must be maintained through reapplication and not be allowed to deteriorate through disuse. If we state an idea or a principle and never come back to it with applications, that idea is lost to the memory of the student.

Mr. Jessup writing in the thirty-eighth report of the Carnegie Foundation for the Advancement of Teaching says: "An active mind requires, and in reality seizes, its own leeway in choosing what it will ignore and what it will digest." Since minds and memories are made as they are, it is folly to act as if all pearls are grasped and held in a retentive memory. The following table will give a suggestion of what I mean and it may indicate methods of teaching which we have overlooked.

Forgetting of a College Lecture		Of College Study
Lapse of Time in Weeks	Per Cent Remembered at that Time	
0 (end of lecture)	75–80	90–100
1	35	45
2	30	38
3	25	36
4	23	35
5	20	From here on
6	18	25–35
7	17	
8	16	

Then comes the examination at the end of twelve weeks for the quarter or after sixteen weeks for the semester. Unless some special device is used to emphasize the material, it may all be in the last 84 per cent for lectures and if not repeated it may be in the forgotten 65 to 75 per cent for assignments. If these results are approximately true we should certainly take them into account when we outline the course of study and when we undertake to give subject matter in any field.

All through our lives we are guilty of spot learning. This is due to our methods of study and to the way the mind works. We will build a compartment for some kind of knowledge which keeps it away from some other kind of learning, and in the end we treasure as being true two sets of facts which may be diametrically opposed to each other. For example, the public debt is not a debt at all; it is a device of taxation. After the war the public will be restrained on its works program because of the Federal debt. When we read one plausible authority we accept the one point of view and when we read another we arrive at a different point of view. If we seal up the ideas and keep them apart for occasion, we will believe that both can be true at the same time.

Spot learning allows a student to do manipulations in calculus and not understand that he has learned a method of solving problems in electricity, mechanics, hydraulics, thermodynamics, or structures. Some of the trouble comes from the concept that we are learning for learning's sake and have no desire to dwell in the market place. Learning is not learning unless it has some connection with the science and art of living.

As a third educational fault we have the course credit virus. Under our present mass production methods we seem to need some kind of an account with the registrar, but it cannot possibly show educational achievement. It

cannot take account of the variations in memory; it cannot distinguish between rote learning and understanding; it cannot measure the "Love of learning which rules the world." Is it possible to place in the record the differences in the knowledge of the truth? One student may take it on the authority of the professor, one may believe because it is of ancient origin, and another may believe because the statement conforms to all his other knowledge of life and action. He who has appropriated a principle as a part of his working processes has become to that extent educated. A mark with the registrar cannot detect real appropriation.

Out of the mark with the registrar comes most of the cheating, the shallowness of learning, and the quick forgetting of course work. If it once gets on the record it is there as credit toward graduation. Somehow it has become one of the sacred archives of the student's academic progress. It somehow contains the blood, sweat and tears of the student and professor. Committees on degrees and deans of students think that by keeping good records of this kind they have performed their educational function.

Students should take courses for two reasons. The first to make study of a certain area of knowledge and second to see how the mind of the professor works. If they get no knowledge or fail to see the professor at work, they have missed the boat, yet they may be able to get credit with the registrar.

One of the greatest faults of present educational methods is the failure of students to believe that learning is worth while. We sing the motto but we do not believe that love of learning has anything to do with ruling the world. More often we hear: "Thank God, that is over." We have even fallen into the fallacy that difficult courses have more disciplinary value than other easier courses. Is the learning process akin to tugging at heavy weights or is it like walking in the garden in the cool of the evening?

Woodrow Wilson said that in the college the side-shows had run away with the circus. In many cases just that is true. The fraternity, the club, athletics, courses given between nine and twelve o'clock and no higher up than the second floor have diverted the attention of the student from his education. Conversations are not of an academic nature. In student and faculty gatherings the conversation does not turn to learning but to the games, the girls (or boys), the show, etc. Here is opportunity for real learning.

The preacher said in the Ecclesiastes: "The words of the wise man are as goads." We are more willing to chase the will-of-the-wisp than those who are wise among us. As a matter of fact we have almost lost our ability to distinguish the wise from the foolish.

How can we begin implementing the outline? First we must recognize the limitations of memory and the use we are making of the knowledge the student has gained. Instead of disparaging the instruction that has gone before we should undertake to tie more instruction to a student's previous experience. It may be that they cannot multiply, cannot spell, or cannot integrate, but they have a right to forget something. If we apply our instruction with the idea that they have been exposed to certain fields of knowledge, in their previous study, and try to resuscitate their memory in these fields, we will present new knowledge with a better chance of success.

Scientific-Technological Stem

We should tie our technology to general principles which are basic. A whole book on strength of materials may expand a few general principles and a few definitions. Then may be added a swarm of details. If the student is given the details without the over-all picture he is lost in a maze of things he cannot understand.

Probably the greatest offender in this field is found in the Department of Physics. We have examined a number of texts where topics are listed by the hundreds. As a matter of fact we know of a text which has 1,500 different items presented to the student. No student can be expected to remember such infinite details.

Probably the greatest criticism of our instruction in the scientific-technological stem is the presentation of great masses of detail. From the very nature of the work some detail is necessary but we should never lose sight of the principles we are trying to present.

The Committee has aptly stated the objectives we should try to attain, and our experience as teachers has shown us how to accomplish the desired ends. We will not, therefore, undertake to dwell upon this phase of the report.

Humanistic-Social Stem

Here we may prepare for discussion and for differences of opinion. The reason is quite obvious. We have confused this stem of our instruction with culture, liberal education, the fine arts, and general training. None of these terms have been adequately defined. Somehow we have hoped for a series of courses which will give us all the training we need outside our technology. We have been rather dogmatic about the technology but too often we have been on unstable ground when we have talked about general subjects.

The Committee has clarified the aims and objectives. The outline is clear. We should not allow the outline to be as a valley of dry bones which are exceedingly dry, but rather, we should fill in the meat until the bones shall live.

A number of institutions have had experience in these areas. They can tell us what they have been able to do; they can also tell us what they have not been able to do. My first suggestion then is to learn what Dr. Doherty has done at Carnegie Tech., what has been done at California Tech., and at the other colleges of engineering where experience has been accumulated. With a background of their experience we can attack the problem with a little less prejudice.

I am convinced that a series of course credits in history, government, economics, sociology, and psychology is not the answer. The Committee suggests a sequence of courses designed to attain the objectives. Surely the last word has not been said in these fields and we must take the books now written as we find them without future change. We cannot take a page or a chapter here and another there and attain our objectives. It may be that new course materials must be developed for our purposes.

My first approach to the problem was to get a meeting of the professors giving formal courses in the subject matter areas. I then tried to state our problem and ask their help in getting a solution. Some believed that a few added hours of instruction in their fields would do the trick, others saw that a joint program coördinated by the engineering representative or a

committee from the whole group might reach the desired goals.

We probably know what should be done in first year English. Further instruction in language should probably be studied by the joint committee. We have had years of experience in the field of economics but we have not accomplished the objective set for ourselves in the subject. This area should be studied along with additions to the present program. It may take us several years to develop usable subject matter, desirable sequences, and correct emphasis.

The Committee suggests a minimum of one course of say three hours each year throughout the four years. More time may be needed as the program takes acceptable shape. No one will be childish enough to believe that all the needed instruction in these wide areas can be obtained in the manner suggested. But out of the experience the student should develop a discriminating taste, a selective appetite, and a desire for more knowledge in the fields. As he acquires educational stature, he will be able to fill in the outline made by the Committee and begun by the coördinated program.

Unity of Program

This brings us to one of the first aims of our engineering instruction. We should state the over-all objective of the program, then state the objectives of each course and show how they fit into the over-all picture. Again and again the over-all picture must be stated if the student makes progress in the course. "It is only by the most careful planning in which the strictest attention is given to the adopted objectives and only such subject matters and procedures are included in the curriculum as are essential to their attainment." This is using the words of the Committee. I cannot over-emphasize the importance of this activity.

A few years ago we undertook the statement of the objectives of the courses in civil engineering. We prepared an over-all statement and then tried to fit each engineering subject to the general pattern. Our statement was not complete, but it gave the staff a picture of what they were trying to do. If the work is outlined and the instructor follows the outline the student will always be able to determine the path along which he is traveling. Again the Committee states: "Explicit objectives must be formulated not only for the major portions of the curriculum but also for each of its subdivisions in terms of the knowledge to be acquired and abilities to be achieved." At first the outline may seem to be as dry bones, but as the meat is filled in the outline will take life and have meaning for the student.

Be sure that all instructors in the course are traveling the same road. This can be accomplished by staff meetings, by discussion of subject matter and methods of presentation, and by coördinated schedules. Much of the value of the laboratory instruction is lost because it is not coördinated with lectures and recitations.

We must approach the task knowing that the art of engineering practice cannot be conveyed in any single subject or even in a series of subjects. It is a long time job which will require much effort on the part of the beginning engineer. If the instructor can start the young engineer along this path, he may ultimately acquire enough knowledge to perform with requisite skill. The engineering method, the engineering attitude, and the engineer-

ing approach must be constantly emphasized in order that the student may become familiar with these qualities.

Creative Ability

We have just emphasized the method and approach and we will add one other tool and that is research ability. Some employers like to call it creative ability. Again and again they ask our staff members to name those students who have originality or those who can work under their own steam and power. We should arrange at least a part of our work to encourage research or independent work ability. The Committee's report suggests that the problem method is the best method available. They suggest that beginning with the junior or the senior year the problem method may be used. I would go back to the first year and introduce the problem method. Let it apply to beginning Math., beginning Chemistry, and then follow through each year of the whole program making sure that the problems illustrate principles and give the student an opportunity to develop original solutions.

Much of the practice of the successful engineer is the solution of engineering problems. They may be much more elaborate than the elementary tasks given in class but the technique and method of approach are the same. As the student matures larger problems and more elaborate solutions will be required. I recommend that we revive the old student thesis and see to it that each graduate does some original work before he is given his degree. You may say that this is over-emphasis of a special technique but to my way of thinking it is very difficult to divorce the engineering method from the laboratory and the research approach.

Good Teaching

The key to the whole problem, of course, is good instruction. No progress can be made unless the staff is interested in the growth of the student. Some way must be found to cause the staff to act as a unit. We have already suggested staff meetings. This may be extended to larger groups who devote time to the actual problems of instruction in the college. We have had very great success with meetings of the younger men on the staff who have been willing to study methods of giving instruction in the lecture room, recitation room, and the laboratory. They have studied the standard procedures recommended by our brethren in the College of Education. It seems to me that we have been so prone to criticize the College of Education that we have been unwilling to profit by the techniques they develop. I would not spend four years in college trying to learn how to teach, but I would spend some time trying to learn the techniques discussed by writers in education. Group meetings can be used to great advantage for discussions of this kind.

In any active college of engineering there will be rivalry for the student's time. This is desirable, but to hoard students' time is unnecessary and pernicious. If the time allowed to a subject is more than is needed to cover the outline of that subject and the instructor is allowed to pad the course, there is great waste of the student's time and loss in the college's effort to produce the kind of product we desire. In this connection I would suggest something that is rarely undertaken in the engineering colleges:—staff visits to classes conducted by other members. We have built up the educational taboo that the

classroom is the fortress of the individual instructor. When other persons visit we call it snooping. The opposite point of view should prevail. Since all the instructors are trying to work as a team they should welcome visits from other staff members and they should appreciate constructive criticisms. Nothing, of course, could be more damaging than destructive criticism.

With some trepidation I suggest a few things a teacher should do.

Positively:

Consider students as individuals. The assembly line and mass production are satisfactory to the manufacturer of goods and materials but they have no place in education. Even the lecturer must approach his task as if he were an individual talking to individuals and not shooting at a crowd. Students must be able to bring their problems to the faculty and get sympathetic treatment, yes, more than sympathetic treatment, they must be able to get educational advice which will direct them along their search for knowledge.

To be a guide, and not a sign post only, the faculty member must have traveled the path before the student. It is hard to inspire to productive effort if the teacher has not been a producer himself. By producer we do not mean, necessarily, that the teacher must have written some dry tomes to be required of students, but rather that the teacher has been over the ground, has studied the way, and knows the short-cuts as well as the long way around.

Students naturally take to specialization. They can understand how practical knowledge may be of benefit in after years. It is a much more difficult task to interest them in general principles which may apply in the many problems of life. It is easy to repeat Newton's first law, but it may take a genius to follow all the implications of it. If students realize that Newton developed the law after much observation, they may begin to understand that it is more than a rule; it is the beginning of understanding of mechanics.

Negatively:

The faculty should avoid incidental disservices. No professor would bring a biting dog to class, yet one of his neighbors may be guilty of keeping one. This is often more than an incidental disservice—it may be a studied plan to get even. Faculty should avoid sarcasm and biting criticism. Students are not supposed to be as wise as professors or they would be the teachers and the professors would be the students. Hunt down error wherever it exists, but make the student be the discoverer rather than the culprit who has strayed away and who resents correction.

Avoid losing the student in detailed solutions. Often the report is so long and laborious that the student forgets what he is trying to learn in his effort to produce words, pages, and pictures. Never allow the student to miss the point of the exercise by getting lost in the manipulation.

Avoid great delays in returning corrected work for student review. Oftentimes the student makes the same mistake a number of times in succeeding exercises because the instructor has failed to return graded papers until after it is too late to profit by constructive criticism.

Avoid diverting the student's attention from the lesson by forcing him to

meet rules and regulations. A minimum amount of rules and discipline are necessary, but don't lose the student in the rules to the disadvantage of his learning. Size of lettering, width of margin, and outlines have their place, but don't become slaves of these details. In some exercises the student may improve on the model if he is allowed to use his imagination. One of the greatest stumbling blocks in the way of the student is to require him to present material in a restricted form which does not allow him any originality.

Students should be trying to learn and learning is best accomplished in an atmosphere of freedom and enthusiasm.

How then shall we develop good teaching staffs? The Committee's report suggests that great care be used after the war in building staff back to pre-war strength. It is possible that many competent instructors will be available as soon as the war is over. For many years certain engineering educators have been talking about the things listed in the Committee's report. A friend of mine has suggested that the only way that they can be put into force is for the administrative officers to interview prospective staff members and determine in advance whether they are in sympathy with the improvement projected. I am inclined to believe that by general staff meetings the agreed objectives can be put into operation.

In any college or department the great burden of instruction falls upon the assistant professor. As a matter of fact the assistant professor should be the best instructor on the staff. He has had years of internship and he is not too old to learn. If department heads will visit the classes of their staff, they will find that the best instruction is being given by men in the thirties and early forties. There must be a place for the older staff members, but if they believe they are good because they are old they are about to fall by the wayside in this educational venture.

Magnificent Interlude

Let me close with a point of view which may assist in determining what should be learned in college. It is obvious that no student can learn all that he needs to know, and if he did he would forget it before the knowledge was needed. He must therefore learn as much as he can and in such a way that it will be the most beneficial to him.

Surely any engineer must be a student all his life. College then is but a four-year interlude between adolescence and the beginning of his professional career. It is time designed for study; no similar opportunity will ever come again. If the student can be guided through the period in such a way that he will get educational profit out of his opportunity, he will be well fitted for the continuing study made necessary as he approaches his chosen field of activity.

The Committee has set the objectives of the program. It has urged an emphasis on basic principles and on methods and techniques; it has warned against specialization. Faculties must keep these objectives constantly before the students in such a convincing manner that they will believe in them and try to achieve them.

Design Sequence of Day Engineering Courses, the Cooper Union

By WILLIAM S. LYNCH

The Humanities courses in the Engineering School of The Cooper Union were selected and arranged to complement the scientific courses in method and approach, and to pass from the broad and general to the narrow and specific, from the concrete to the abstract. In designing the curriculum there were three subjects which, for various reasons, it was felt should be fixed and immutable points: (1) English composition, (2) public speaking, (3) economics. It is quite obvious that any program of college studies needs to provide for training in the use of English, for the development of acceptable speech habits, and for some attempt to offset the economic illiteracy prevalent in America.

The freshman English was coördinated closely with an introductory course in Western Civilization, which has as its purpose the collection of historical and social data and the interpretation of them in order that the student might have for his more advanced work an adequate store of general information and in order that he might acquire the mature attitude which only a knowledge of the past's evolution can give to the contemporary. Incidentally, this balances rather neatly the abstract theory of the freshman science courses. The introduction to the historical evolution of social institutions forms the basis of the Humanities program, for out of it come the background materials for every other course and to these other courses they are closely related. Even the skill subjects like English draw for their theme work and readings upon literature that is related to the study of history. It may be interesting to point out that through coöperation with our Museum we are able to offer unusual displays of rich, artistic matter. For example, while as history students young engineers were studying the eighteenth century, in their English class they were reading an eighteenth-century novel and supplementing both by attendance at the exhibition that had been arranged by the Department and the Museum to demonstrate the impact of the East that was occurring at that time. This exhibition, by the way, "The China Trade and Its Influence on the Western Decorative Arts from 1700 to the Opening of the Suez Canal in 1869," attracted very favorable comment in art and museum circles.

To this study of history and English there has been added a course in Geography, an addition which, while in part the result of the war, fits into this pattern. The syllabus of the Army Specialized Training Program is used as a guide to the contents of this course.

In the sophomore year one semester's work is devoted to the above-

mentioned Public Speaking; in the other, the student is allowed to follow his studies into the field of American institutions through a course in Government, in the development of political ideals, or in literature. The idea here was that he could explore within the framework of his own nation's history some significant area of the Humanities in which his interest had been aroused during his freshman year. In the current accelerated program, however, all students must take the same course, American Civilization. While the first emphasis in the speech courses is quite naturally on the elimination of faulty speaking habits, wherever possible the practice subject matter is related to the other courses. Never is it forgotten that even more important than the ability to say a thing well is the possession of something worth while to say.

It is in the junior year that Economics is given. By this time the student should have amassed sufficient information on social institutions to have some sense of their complexities and he should be mature enough so that, properly guided, he will not be prey either to superficial shibboleth or to conditioned stereotypes. It is our honest belief that the current tendency to examine trends without first looking at the facts involved in the formulation of those trends, is ridiculous. It is for this reason, therefore, that economics is placed as late in the curriculum as this. It is our feeling also that economic institutions are best considered in relation to other social institutions; hence in our course economics is considered not only in terms of laws and principles but also as an integral part of an introduction to the social sciences.

In the senior year the majority of students take our colloquium course in Social Philosophy, in which every attempt is made to avoid the conventional classroom procedure. The seminar method is used, with its informal discussions; the students are encouraged to explore the wide variety of subject matter necessary to achieve a sound personal and social philosophy. Their discussions are kept disciplined through their reading of a number of important rigorous and classic volumes ranging from Bacon's "Novum Organum" to John Stuart Mill's "Autobiography." In this way it is hoped that the budding engineers can find the unity of their humanistic training and through the guidance of great minds make it relevant and vital to their whole engineering education. It is worth noting here that the balance of the first year when the factual quality of the Humanities complemented the theory of the sciences has shifted; for now the theory and the philosophic inquiry of the Colloquium are matched by the definite and concrete applications of senior engineering.

We have in the senior year also two small experimental classes: the one following the social branch of the humanistic-social stem, that is, Sociology; the other, the humanistic branch, a course we call Approach to the Arts.

While the accelerated curriculum has been adjusted to a quarter basis, the pattern herein outlined has been maintained.

Toward an Integrated Program in the Humanities*

By FREDERIC R. WHITE
Illinois Institute of Technology

These discussions of education, with which we annually afflict ourselves, turn always on two fundamental and recurring problems: What are we to teach? How are we to teach it? Behind these lies a larger and perhaps insoluble problem: Are the conditions favorable for teaching such and such material in such and such a way? What kind of society, what kind of school, what kind of teacher is necessary for carrying out a proposed program? Having been a thorough-going pessimist during the last decade when liberal education, like most other parts of our social machine, was failing to function, I should like, at this time, to point out a few reasons for optimism.

We humanists—or are we humanitarians?—in the technological schools are fortunate in several respects. We have less academic tradition and hence more flexibility than other types of schools. We are less hampered by the dread incubus of departmentalization, with its vested interests, its internal struggle for power, its artificial segregation of humane learning into meaningless compartments of languages and subjects. We have, beneath us, students who, however ill-prepared, pursue a definite aim and who ask, therefore, the proper and pertinent question: How does this course help me achieve my aim ? We have, above us, administrators who are scientists rather than professional educators and who are, consequently, fairly open-minded and experimental in their attitude toward the humanities. We have, in short, an opportunity and a degree of autonomy enjoyed by few other schools in the country.

Nor do I believe that there is much real disagreement over what material we should teach. Unlike many universities and liberal-arts colleges which have admittedly dis-integrated their curricula by adding innumerable electives, the technological schools are continually forced to concentrate on essentials. This frees us from debate over trivia. In spite of inevitable differences in emphasis, there is general agreement that the essential material in the humanities falls within the relatively small class of the best that has been thought and said in western culture.

Other things being equal, the scientist who has read and partially understood the Bible, and/or Plato, Lucretius, Augustine, Dante, Descartes, Voltaire, Marx, Darwin, Lincoln, Tolstoi, Freud, Dewey, James, etc., is more valuable, both to himself and to society, than he who has not. For these men, unlike the compilers of textbooks, give us the most significant statements that man has yet been able to formulate on human affairs: the vision of a more just and equitable so-

* Presented at the 50th Anniversary meeting, S.P.E.E., Chicago, June, 1943.

ciety as in Plato, More, or Bellamy; the tentative first steps toward a method of human engineering as in Jefferson, Marx, Dewey, or Freud; invaluable hints toward more productive modes of thinking, as in Plato, Aristotle, Abelard, Descartes, Kant, Whitehead; the achievement of personal serenity in a world of turmoil as in the lives of Socrates, St. Francis, Thoreau, or, more recently, George Washington Carver; significant descriptions of human energy as in Oedipus and Antigone, Macbeth and Othello, Madame Bovary, Raskolnikov, and Captain Ahab. These are hints toward a better life—fragmentary perhaps, but the only hints we have and the only means, so far as I know, of inculcating a social or non-acquisitive, peaceful or non-imperialistic, humane or non-brutal attitude toward life.

If there is, even among scientists and administrators, general agreement at least on the class of humane material, is it possible to be equally optimistic about the method of presentation? I should be inclined to feel that no method, however bad, could quench the vitality of the "Republic," the "De Rerum Natura," "Candide," or "Faust," had I not personally experienced with each work the results of philological scholarship, working within its narrow compartments of language. The philological method in its present, pedantic form has ceased to be a humane discipline. It is merely an excuse for pursuing grammatical minutiae. And the historical method, which seeks to elucidate the nature and significance of a humane document by recovering its original, vanished environment, has, in my biased opinion, also failed to live up to its promise. It has become an excuse for pursuing historical minutiae. The method of semantics, which studies humane documents in terms of neuro-semantic reactions, is, at present, not sufficiently formed to be evaluated. There is, however, a method long associated with the humanities, familiar to all scientists, and universal in its application, which deserves special consideration, particularly by humanists in technological schools. This is logic, or the formal study and application of scientific method.

I should like, if you will forgive the wanton cruelty, to preface my recommendation of logic by recalling our painful years in graduate school. The training there, you remember, fattens the future scholar in humanities by feeding him Gothic, Anglo-Saxon, and Old French, by stuffing him with plums of literary history, and by moistening him with the cool waters of bibliography. It peppers him with past periods and salts him with Attic aorists. Then, after such a varied repast, it sends him off in hot pursuit of a thesis subject, to return, some eight or ten years later, with several hundred ill-digested but heavily annotated pages. These are generally execrable; not even their perpetrators love them. They invariably go to one of two extremes. Either they present a random assortment of unassimilated facts leading to no conclusion at all, and thus are literally non-sensical; or they leave the facts far behind and push on to a wilderness of unwarranted conclusions. My own, I confess, fell neatly into the second category. It was the outward and symbolic sign of an inward leaping at conclusions. And, like the others, it was execrable.

Why do graduate students, supposedly trained in research, commit such atrocities? Exactly because they are not trained in research. Their

misuse of evidence would give a scientist or logician the creeps. Their inability, at one extreme, to draw any inference at all from their material is only equaled, at the other, by their unwillingness to check hypotheses against the data. Nor is this to be wondered at, for there is nothing in the various disciplines of Anglo-Saxon, Old French, literary history, or bibliography which acquaints one with the laws of evidence. These studies may furnish examples of valid inference, but they are not even a poor substitute for direct study of valid inference. Unhappily, logic, the discipline which does study the proper use of evidence, is no longer a denizen of our academic zoo. In a decade of haunting the groves of graduate study, not once did I hear a professor of the humanities mention this forbidden fruit. Apparently, anyone interested in such illicit information should read up on it surreptitiously behind the barn, or perhaps soak it up by a kind of intellectual osmosis.

Yet the discipline exists; several rather good books have been written about it; scientists often mention it, even in mixed company; and our students, of course, employ it consciously or unconsciously in almost every scientific course they take, since it is indispensable to research in any field. That logic, or scientific method, lies at the very heart of the sciences is obvious. That it is equally applicable to the humanities can be very easily demonstrated. For it is basic to the very process of education, insofar as that consists of drawing conclusions from (usually insufficient) data. It is basic to expository and argumentative composition, the two kinds of writing with which we are chiefly concerned. And it is basic to an analytic study of any expository or argumentative document, the two kinds of reading with which we are chiefly concerned.

In history, for instance, such an hypothesis as that of Spengler must account for its data in exactly the same way as an hypothesis of molecular structure or sound waves. In economics the formulation of a "law" of supply and demand must likewise explain the phenomena or be discarded. In literary criticism, such a broad hypothesis as that of Kenneth Burke, that literature is symbolic strategy for encompassing a particular psychological situation, must likewise account for the data, or be abandoned. Incidentally, the failure of Burke's hypothesis to account for the whole body of anonymous literature, the Bible, Homer, Beowulf, the ballads and sagas, limericks, popular jokes, etc., suggests that it has, at best, only limited applicability, and hence is untenable.

All formal study in the humanities, as in the sciences, consists in making verifiable statements about the investigated object. These may range from simple statements, based upon the simplest kind of evidence, such as "This book contains three hundred pages" or "Hamlet kills Polonius in the third act," to the most complex conclusions drawn from complex data, such as "The symbolic values of the fifth book of Rabelais are in direct contradiction to those of the first and second books," or "The social attitude revealed in 'The Tempest' is similar to that in Plato's 'Republic.'" Adequate presentation of the evidence for such statements results of course in student compositions, doctoral dissertations, and scholarly works. That is why logic is necessary in the humanities.

My point is only that in the humanities, as in the sciences, we are contin-

ually engaged in attempting to reach certain verifiable conclusions or to formulate certain tenable hypotheses, and that this process is exactly that which logic explicitly and formally studies. It is in this sense that logic is truly *scientia scientiarum*, the science of sciences, not that it is over or above the sciences and humanities, but that it is in them. Logic as a method, then, does not exclude other methods of gathering data. The exhumation, by the historical method, of buried data, the search, by semantics, for neural responses, even the formulation, by intuition, of subjectively-generated statements about literature are all presupposed by, and included in, logic. And since logic is the most inclusive of all methods, being itself the formal study of method, it is, naturally, the most widely applicable. And it furnishes, for our purposes, a most useful connection between the technological sciences and the humanities.

If there is widespread agreement on the subject matter of the humanities, and if there is, ready to our hand, an applicable method, is it possible to form from them an integrated program of study for the technological students? There is not, so long as we wish to retain our present unintegrated courses in composition, history, political science, literature, philosophy, and the rest. Yet if in their place we substituted eight three-hour courses, one a semester, each uniformly devoted to the analysis, discussion, and composition of papers upon some four or five classics of western culture, we could give technological students an introduction to the humanities which very few Ph.D.'s possess.

They would then be trained for four years in the application of scientific method to the humanities. This should cure them of that common complaint: "I can't read a good book; I'm just an engineer." They would be trained for four years, instead of one as at present, in the composition of argumentative and expository writing. This would meet the objection that our current freshman composition courses have vanished into thin air by the time our students are juniors and seniors. They would, in twenty-four hours of formal education, become familiar with forty, possibly fifty, of the world's greatest writers. At present it is highly doubtful if they have a nodding acquaintance with four or five. They would have, as a result, a sound basis for further reading in what are at present the unrelated fields of the humanities. They would miss, happily for them, the current textbooks in these fields. But we, if we truly believe in the efficacy of the humanities, should not be too dejected at the thought of replacing Willey and Scott by Shakespeare and Voltaire, or Taussig by Marx and Veblen, or Hayes by Plato and Hobbes. The engineer does not need to be a specialist in comma splices, contracts, or constitutional law. He does need to know how to write, how to read, how to think. This he can best learn from those who have done it best. And it is surely not an inauspicious omen that such a program moves from the second-hand and second-rate to the first-hand and first-rate writers of the western world.

If we, as undertakers, were willing to bury our textbooks and recommend such a living program in the humanities, is it possible to assert that present conditions are favorable for such an undertaking? I think it is. For it is becoming widely recognized that the techniques of applied science are a-moral and a-social. They have no

aim beyond efficiency. They can be used as well for the destruction as for the preservation of life and society. The technician as such has no concern with the relation of his work to human welfare, and this constitutes a threat to society that becomes increasingly dangerous as the techniques become increasingly efficient. Indeed, in an acquisitive and imperialistic society, whose sole principle of action is "top dog take all and devil take the hindmost," applied science will, quite obviously, serve rather the interests of private profit and aggression than the interests of public welfare and peace. Neither in war nor in peace do the technical sciences provide an aim or goal for their own application. That goal is furnished by the society in which they operate.

Recognition of this truism leads to three optimistic, or at least consoling, conclusions. Since the use to which technology is put is dictated largely by society, it is obvious that education has only a limited, not, as is too often said, a total responsibility. For some years the schools have been whipping posts for our modern discontent, and the poor educator gets spavined and winded as he patiently shoulders most of the blame for cultural lag. There is no reason that he should. By and large societies get the schools they deserve. One need not point back for examples to Athenian versus Spartan education, or to the failure of Rome to develop any liberal education whatever. One can point to Germany and Italy, and to Russia. Formal education, we are at last coming to recognize, is only a very small part of the total education that goes on in the home, in the factory, in the beer-parlor and pool-room, through the newspaper, radio, and other channels. Hence, formal education, only one of many channels of information and misinformation, is not, by itself, responsible for the character of society. Only if formal education could control all channels of information would it be in a position to alter the character and aims of society, and be liable, therefore, for the total damage.

Again, the realization that society must exercise control over the application of technological forces poses within each country of the world the basic problem of fascism versus democracy. Fortunately, there are some signs of social change. The breakdown of acquisitive society in the thirties; its inability to function independently during times of war; and the widespread dissatisfaction with its aims and methods, all suggest that conditions may soon make possible a socially-useful, humane education—or none at all. Either democracy will be successfully extended from the political to the economic and social spheres, or it will disappear beneath a universal wave of fascist reaction. In the latter event, we shall, I hope, be dead. In the former event, the extension of democracy will demand an education dedicated to the preservation of humanity and the humanities.

And finally, though formal education cannot legitimately be charged with the total responsibility for undesirable social attitudes, it must accept its limited responsibility. It can and must, in these times, justify its existence by seeking to ameliorate the rigors of our acquisitive society. That this is particularly necessary in technological schools whose graduates may soon dominate society, few would deny. That it is being done very satisfactorily at present, few would affirm. Yet this comparative failure is, of course, a

necessary condition for change and for the eventual success of an integrated program. Just as the failure of acquisitive society brings an inevitable demand for social reconstruction, so the comparative failure of our unintegrated education creates a demand for a more efficient program. These conditions and these demands, together with the peculiarly favorable position of the technological schools, warrant some optimism over the future.

In seeking to use formal education as a channel for inculcating a socially-useful, or humane aim, looking rather to the preservation than the destruction of society, the technological schools are in a fortunate position. They enjoy the good will of society because of the popular worship of science. They are relatively free from the artificial and harmful division of the humanities into such linguistic compartments as Greek, Latin, French, German, English and into such inapplicable subject-matter departments as "history," "economics," "political science," "philosophy," and "literature." Not greatly burdened with ancient vested interests in these fields, the technological schools are free to organize the humanities in the way which seems to them best.

Moreover, they are free to acquire men willing and able to transcend these artificial limitations. They are not, like the universities, forced to invest heavily in specialists and then justify the investment by turning the specialists loose on the unsuspecting student. A university, if it is to be a true repository of learning as well as an educational institution, must necessarily have its authorities on Oscan, Umbrian, and Tuscan, its specialists in fourth century law and twelfth century medicine, its narrow investigators into the minutiae of ancient learning. This academic burden need not fall upon the technological schools; they can neither compete successfully nor realize any profit from such an investment. They are free, then, to invest in scholars rather than in specialists, in teachers with a broad acquaintance with the humane tradition of western culture rather than in pedants with a limited field of interest, in men who view education as a means to a social end, not as a solipsistic end in itself. They are in a position to insist that instruction profit, not the instructor, but the student.

This is a paradoxical situation. The technological schools, so often accused of wrecking liberal education, are the very schools best able to encourage a renaissance of broad scholarship against narrow specialization, of learning against pedantry, of humanism against philological pomposity. That they are not likely to do so of their own accord seems obvious. But the opportunity is there to be seized. And what prevents the men who really believe in the humanities from seizing it? Nothing but our own lethargy, our own vested interests in specialization, our own inability to rise above our particular fields and present an intelligent and integrated program in the humanities.

Relation of Technology to Humanism in Goethe's "Faust" and in the Works of Saint-Simon

By NICHOLAS M. OBOUKHOFF

Research Professor, The Oklahoma Agricultural and Mechanical College

. . . Minds, that dare explore
the secrets soundless
In boundless things possess a
faith that's boundless
"Faust," Part II,
Act I, Scene IV

The period of approximately fifty-five years whose landmarks are such events as The American Revolution (1775–1783), on the one side, and The Revolution of 1830,* on the other, *is similar to our era* in that both periods present the characteristics of violently intense, wide-spread and penetrating upheavals in all aspects of life following each other in a rapid succession and shaking the very foundations of individual, social, and intersocial (international) relations. An epoch approximately seventy-five years long stands between those two periods; it shows traits of a *relative* stability and can offhand be called evolutionary.

Using a few broad strokes of a brush one can depict this era (1830–1905) in the following characteristics: (1) an unprecedented development of science and scientific technology accompanied by a prodigious industrialization of society; (2) a wide-spread spirit of social humanism pervading the whole society, at times vague but still potent enough; (3) a continuous progress of democracy mainly by evolutionary steps; (4) strong social movements within the frame of an established order as a rule but of course with some exceptions; (5) a firm web of intersocial (international) interdependence growing closer and tighter with time.

Using again a landmark for historical orientation it is suggested that this era of a relative stability terminated and ours began with the Russo-Japanese War (1904–1905).* Then there followed a quick succession of events: The First Russian Revolution (1905), the counter-revolution (1906), the Revolution in Turkey and annexation of Bosnia and Herzegovina by Austria (1908), the Chinese Revolution (1911–13), the Balkan Wars (1912) and the World War of 1914, etc., to date.

Of course, it is understood that the schematization of the periods is a device for an easier orientation and that in fact every era conceals within itself

* This event marks the beginning of the more liberal era in the history of Europe, which gradually replaced the reaction that had established itself after the Great French Revolution. Also it signifies the closing of the entire revolutionary cycle with the usual phases of origin, culmination and counter-revolution.

* In view of the present day international situation this landmark does not need a justification: it speaks for itself.

germinating elements of the following one and contains some vestiges from the preceding period. It is realized that especially turbulent and stormy periods of history are accompanied by manifestations of a general shake-up in science, valuation and ethics and in their mutual relations as well.

Accordingly, it is thought that historical parallels would not be amiss as they may assume significance for the present day actualities.

Both Goethe (1749–1832) and Saint-Simon (1760–1825) belong to the same era of the great surges first leading to and then spreading from the French Revolution. Significantly, independently of each other, they constructed the relations between science, value, and ethics according to a similar although not identical pattern in their solution.

Also Saint-Simon had a vision of the unified science, looking first for "the general science," probably "the science of sciences" in modern terminology, and then for "the general idea." Finally he realized that the problem was not ripe for a solution.

Comte (1798–1857) repudiated Saint-Simon's coördination of science with Christian ethics and broke away from him.

Later, however, toward the end of his career Comte felt the need of an ethical principle establishing a universal goal; thus he created his cult of humanity. It was a relapse toward Goethe and Saint-Simon but it could not equal the glowing apotheosis of integral humanism in the second part of Goethe's "Faust" (1832) nor the forcefulness of a broad nonconformist religious inspiration in Saint-Simon's "The New Christianity" ("Le Nouveau Christianisme," 1825).

Goethe of the earlier period rated the practical aspect or actualities of science * pretty low: in the words of Faust of the first part of the tragedy (1808) bearing the same name Goethe says:

> I don't think much of what I know,
> I don't imagine I could show
> How men could mend their ways
> Or help them on to better days.

Further in a dialogue with Wagner (his assistant), Faust retorts:

> O happy the man who hopefully aspires
> Out of sea of error to arise!
> What man knows not, is just what he requires;
> What man knows he cannot use in any wise.

The instances of this attitude are *not* casual: besides being numerous they are perfectly consistent with other aspects of the first part of Faust and are integrated together with them into one whole. The intended incisiveness of the contrast between Faust and his antipode Wagner † makes for an overwhelming emphasis on Faust's attitude of dissatisfaction with science.

Besides this, however, there are *in the background* few pronouncements—*very few in fact*—made on science *"in the abstract"* and relating to its potentialities rather than its actualities. They are positively appreciative,‡ yet they

* *I.e. "in the concrete."*

† For instance, while discoursing with Faust he says: "I know so much—still, all I'd like to know."

‡ For instance, in the words of the Lord: "What in wavering apparition ('Erscheinung') gleams—Fix in its place with thoughts that stand forever!" Prologue in Heaven. Part I.—Likewise, in the words of Mephistopheles: "Reason and knowledge. . . . The highest strength that lies in man!" Scene IV: The Study. Part 1.—Both excerpts in the translation by Bayard Taylor.

do not refute the foregoing judgments passed on science *"in the concrete."*

The first part of Faust belongs mainly to the eighteenth century—to its closing period; then practical applications of science were limited; notwithstanding the progress of eighteenth century science, scientific technology and industrialization were still in an incipient stage. In accordance with the epoch Goethe showed an emphatic restraint in an appraisal of the actualities of science, while believing in its potentialities.

There follows now another interesting passage from the first part of Faust:

Ye instruments, ye jeer at me, I feel,
Cog and circle, cylinder and wheel!
I stood at the door, ye should have been the key;
Though fashioned well, ye raised no latch for me.
Unfathomable by light of day,
Nature will permit no one to steal
Her veil; *what to the spirit she will not reveal,*
With lever and screw you cannot wrest away. . . . (Italics by the writer)

Here in the words of Faust, does Goethe disclose his comparative valuation of both the abstract ("spirit") and empirico-technological cognitive methods ("instruments . . ." "lever . . ." "screw . . .") and he concludes:

That which is useless is a heavy burden. . . .

One *must* concede that at that time Goethe's judgment was not in favor of the empirico-technological science: a very strong note of a decided though friendly scepticism is sounded there and accepted very loudly.

Yet his affirmations of the *science "in the abstract" are casual, almost perfunctory throughout the tragedy.*

There is much imagery, fire and color in the negation of the value of *science "in the concrete."* Its weakness in application to life is exposed vehemently with passion, in the "flesh and blood" manner, while the recognitions of abstract qualities of science come after an unemotional pattern of philosophical aloofness.

Yet Goethe was right: the eighteenth century thought had almost been an uninterrupted song of praise * to reason and science until in the end it became somewhat trite; in its *relative* naiveté it had let it pass unnoticed that the abstract qualities or potentialities of science had been affirmed and established at that time rather than its actual extensive applications to human life. Goethe boldly pointed out this insufficiency: while not insisting on what had become trivial he showed much solicitude and concern for the realization of the potentialities of science in the world of human realities.

The *second* part of "Faust" is connected with the period when the potentialities of science began to transform to actualities in a manner promising an unprecedented success. It was the first third of the nineteenth century: the beginning of the steam and coal age on a much larger scale than in the closing period of the eighteenth century, just to mention only steam railroads, steamships, thermodynamics with its applications, etc. . . . In three decades France and Prussia became industrialized states, while England reached the new heights of technological development.†

* With the outstanding exception of Jean Jacques Rousseau and George Berkeley among the greater thinkers.

† Certainly just as important were the social and political changes in Europe that followed the Great French Revolution and The Napoleonic Wars.

Also Ampère, Gauss, Oersted began laying down the scientific foundations for our electrical age.

Accordingly, the second part of "Faust" (1832) exhibits the spirit of practical confidence in science. There Goethe displayed a whole system of its values: its intrinsic and inherent values and likewise those derived and obtained from science.

Furthermore, higher and even *supreme values of ethics* enter this system *as the foremost objectives for science to strive for;* thus they *impart an ethical value to science* in so far as the latter is inspired by and coördinated with ethics.

All these values in their variety appear to be as follows:

1. Control over Nature.
2. Self-assertion of an individual and his increased capacity for action. For instance, listen to Faust of the second part of the tragedy:

> Mine eye was drawn to view the open Ocean;
> It swelled aloft, self-heaved and over-vaulting,
> And then withdrew, and shook its waves in motion,
> Again the breadth of level strand assaulting.
> Then I was vexed, since arrogance can spite
> The spirit free, which values every right.

and again

> Here would I fight—subdue this fierce uproar!
> And possible it is! . . .
> *So, swiftly, plans within my mind were drawn:*
> Let that high joy be mine forevermore,
> To shut the lordly Ocean from the shore,
> The watery waste to limit and to bar,
> And push it back upon itself afar!
> *From step to step I settled how to fight it:*
> Such is my wish.

The passages just italicized by the writer in this excerpt are descriptive of the *essential characteristics of scientific technology.*

3. Personal Prosperity.

Goethe is no rigorist and he does not belittle the value of personal prosperity providing it is earned by a strenuous activity;* he shows us Faust always in action even after he became rich and prosperous. Science for Goethe means action and striving, it is *science for and of action;* in other words, *it is technology in a broad sense of the word.*†

4. Aesthetic Value.

Having science at his service, Faust beautifies the country around his palace.

Here we are approaching the catastrophe which will, according to Goethe, show how the entire structure of values described in the foregoing collapses if the supreme law of love for mankind (social humanism) is not there to control and coördinate them.

Faust overburdened with age is still a dissatisfied and discontented man: there remains a swamp that challenges his action and an old-fashioned decrepit

* "He only earns his freedom and existence
Who daily conquers them anew."
"Faust," Act V, Scene VI.

† The above characteristics appear in "Faust" in terms and images of technology in a restricted sense; it is obvious that the latter serve as symbols which convey more than what they are.

residence of an old couple hurts his aesthetic sense. These old folks are stubborn, they would not sell their property at any price or for anything, and at times *Faust gets impatient.* Playing on Faust's longing for beauty, Mephistopheles arranges for the murder of the old couple, without a slightest knowledge and encouragement on the part of Faust.

Grief overcomes Faust and care blinds him, nevertheless he continues his restless efforts to drain the swamp.

Let us listen to him:

The night seems deeper now to press around me,
But in my inmost spirit all is light;
I rest not till the finished work hath crowned me . . .
. . . *Make grandly visible my darling plan!*
Seize now your tools, with spade and shovel press;
The work traced out must be a swift success.

Again the italicized passage describes the essentials of scientific technology. Note how insistently and hopefully does Goethe return to the same theme of scientific technology and its main characteristics in the second part of "Faust." What a change in the attitude from the first part!

Finally:

Below the hills a marshy plain
Infects what I so long have been retrieving;
This stagnant pool likewise to drain
Should be my latest and my best achieving.
To many millions let me furnish soil,
Though not secure, yet free to active toil . . .
. . . A people I fain would see
Stand on free soil of people free!
Then dared I hail the Moment fleeing:
"Ah, still delay—thou art so fair!"
The traces cannot, of mine earthly being,
In aeons perish;—they are there!—
In proud fore-feeling of such lofty bliss,
I now enjoy the highest Moment,—this!

Here is the triumph of love for mankind and Faust, who dies at that moment, is saved:
In the words of angels,

The noble Spirit now is free,
And saved from evil scheming:
Whoe'er aspires unweariedly
Is not beyond redeeming.
And if he feels the grace of Love
That from On High is given,
The Blessed Hosts, that wait above,
Shall welcome him to Heaven!

We conclude

5. That in the second part of "Faust" science appears mainly as knowledge arranged to gain partial control over nature and human life and to assist and stimulate man's action first of all for the benefit and welfare of humanity. Thus Goethe enriches the humanism of the first part of the tragedy, which is *essentially*—although not exclusively *—individualistic, by injecting important social elements in the second part and suggesting an integral humanism.†

Turning now to Goethe's great contemporary Claude Henry Saint-Simon we reach the following conclusions:

1. Saint-Simon's doctrine of relation between science, value and ethics is similar to Goethe's yet quite independent of it; as a matter of fact, the corresponding works of Saint-Simon are slightly *ahead* of those by Goethe.

* See Scene II: Before the City Gate. Part I. Note Faust's friendly and understanding attitude together with a feeling of fellowship toward a common people in contrast to Wagner's aloofness. Faust feels being one with the people.

† The latter does not eliminate its individualistic predecessor and brings about the problem of mutual relation and coördination.

Also Saint-Simon gave his doctrine a social aspect in a more emphatic and outspoken form than Goethe did.

2. *The first period of Saint-Simon's life* terminated with a formulation of that philosophy which is also the essence of "Faust": let us briefly, yet somewhat conventionally call it "philosophy of action and life experience."

In the autobiography (1810), Saint-Simon affirmed a fundamental principle of his that the only way to make a positive progress in philosophy is to proceed through a variety of diverse experiences; that one should, accordingly, "lead the most original and most active life and obtain a thorough knowledge of all *theories* and all *practices*." These tersely expressed tenets appear as an outcome of Saint-Simon's own life experience providing thus more evidence in favor of their spontaneous origin.

Saint-Simon was a living Faust of the New Age. His biographer Maxime Leroy gives this condensed characterization of Saint-Simon's life: "This life rushes from profession to profession, from country to country, from idea to idea with an agitation of a cinema play. It is intense, traversed by thunderstorms and dangers, yet it is beautiful, beautiful with a modern beauty which is all in movement. Saint-Simon lived in haste, desiring to see all, to feel all, to understand all . . . with a hand always pointing to a moving horizon. 'My life has been a succession of experiences,' said he himself."

Saint-Simon will also be remembered in this country as a soldier of The American Revolution; he volunteered in 1779 at the age of nineteen, served with distinction and returned home in 1783.

A scion of an old aristocratic family in France, he fought on a strange soil for the liberty and democracy before The French Revolution; certainly this was a worthy beginning of "the most original and most active life."

Maxime Leroy remarked: "Chronologically Saint-Simon was born in 1760, yet for a psychologist he dates from 1779 the year of his departure for the War for the Independence."

At this place it would not be amiss to give a brief account of Saint-Simon's attitude toward science at the beginning of the nineteenth century since this attitude has a definite bearing on positivism and Saint-Simon's first attempts to establish the unity of "particular sciences," according to his terminology.

Saint-Simon had acquired a good scientific background in the previous years: from 1797 to 1801 he had been connected with the Polytechnic School (*Ecole Polytechnique*) where he had studied "solely the physics of inorganic bodies"—"la physique des corps bruts" in his own parlance—and made friendship with many professors.* Then in 1801 Saint-Simon separated from the Polytechnic School and settled close to the School of Medicine: "I started," wrote he, "relations with physiologists. I had not left them until I got an exact knowledge of their ideas on the physics of organic bodies."

Inspired and led by all these thoroughgoing studies Saint-Simon anticipated a new science, that is: sociology. In "The Abstract of an Essay on Social Organization"—"Extrait d'un ouvrage sur l'organisation sociale"—which he addressed to Fourcroy in 1803 he presented its *résumé* as follows: "After a long rest the human

*Even before, in the years 1794–1797 Saint-Simon had been associated with Lagrange, Monge, Poisson.

spirit rushed forward. The Seventeenth Century produced many men of genius in all walks of life; it gave birth to Newton. During the Eighteenth Century exact sciences made a great progress; superstitious ideas were crushed. What will happen in the Nineteenth Century? The science of social organization will become a positive science. It will be founded on a general observation due to Condorcet."

Later, approximately in the years of 1807–1813 Saint-Simon pondered over the foundations of this new science to come; what he thought at that time is well revealed in his two works: "An Introduction to Scientific Works of the Nineteenth Century" finished in 1808 —"Introduction aux travaux scientifiques du XIX siècle"—and "Memoir on the Science of Man" written in 1813—"Mémoire sur la Science de l'homme." Social physics—"physique sociale"—is the name he uses there to designate the new science; it connotes a naturalistic approach to a study of human relations in a society. According to Saint-Simon, "there are not two orders of things; there is only one and this is the 'physical order.' . . ." "It is necessary to consider social reactions as physiological phenomena" and he hopes that it will be possible to establish "laws of hygiene of social bodies."

Yet Saint-Simon's versatility and resourcefulness together with a sense of reality saved him from one-sidedness: he supplemented the physicalistic suggestions with an historical approach to the problem by presenting an analytical review of a development of mankind. Including both prehistoric and historic peoples, a succession of eleven historico-cultural stages with their characteristics emerged as a conclusion from these studies. In view of the scarcity of authentic information about primitive peoples at that time Saint-Simon did well. Of those eleven stages the latest five refer to the historical peoples: in his last period of life (1817–1825) Saint-Simon will reduce these five stages to three and they will exactly be the same as those advanced and elaborated upon later by his successor, Auguste Comte.*

True to himself Saint-Simon makes an immediate application of the findings: the historical process whose stages in the past he has just outlined is projected or rather extrapolated by him into the present time and next future and he concludes: "We have not yet so shaped the ideas of several laws as to make them converge toward that of the sole law" . . . and further, Europe going through a violent crisis, the task "for the enlightened class is to merge several particular laws into the single and unique law." Thus Saint-Simon's search for science of social organization as a positive science abuts against his other idea: that of the unification of science.

Since 1803 he had been searching either for a unique general principle underlying nature, human life and science, or for a "general science"—*"science générale"*—in a sense of a philosophical doctrine or system,—now and then with religious connotations—that would be demonstrated or based on "particular sciences," that is: in a sense somewhat similar to "Science of Sciences" in present-day positivistic terminology, but not entirely.†

Saint-Simon's previous studies had enabled him to render himself an ac-

* Turgot is credited with having conceived a cruder scheme yet somewhat similar to that of the three stages, in the eighteenth century.

† Religious connotations, for instance, and ethical considerations are not supposed to belong to the domain of "Science of Sciences" as conceived by "logical positivism" or "scientific empiricism."

count of the state of science, in general, and in France, in particular. Not content with this he travelled extensively visiting Switzerland, England, and Germany for the purpose of finding elements of a general science. A disappointment was the result. "No new capital idea," said he of England. "The general science is yet in its infancy in Germany but it will certainly make a great progress in that country before long," wrote he later of Germany in a somewhat more hopeful tone.

His search ends with this conclusion: let us wait until an advanced development of "particular sciences" has made it possible to constitute a "general science."

For Saint-Simon a prospective significance and importance of general science did not lie solely in epistemological unity: he thought also of a function that would unify humanity by general principles abstracted or derived from "particular sciences" such as mathematics, physics, chemistry, physiology, history as added later, etc.; this aspect of general science had in his mind an emphasized socio-ethical value: one of the tasks of general science should be to find social and ethical norms for organization of human life; so overenthusiastic became Saint-Simon at times that he suggested replacing religion by general science or rather lifting the latter to the level of a religion.

These castles in the air collapsed as soon as Saint-Simon himself had recognized that "particular sciences" had not yet developed enough to bring about sound foundations for "general science" to be constructed. Yet the problems and tasks have remained since then as the modern movement for the unity of science has demonstrated recently.

The period of this creative fermentation in the life of Saint-Simon comprises approximately the years 1797–1813.

Aims visualized, problems stated, tasks assigned, failures recognized formed an outcome of those years and all this centered around science as the most important prospective or potential factor in organizing human life.

Goethe's dissatisfaction with the *actual* development of sciences of that period was to a degree similar *in character* to Saint-Simon's: it was expressed in the words of Faust of the first part of the tragedy (1808) as follows:

> I don't think much of what I know,
> I don't imagine I could show
> How men could mend their ways
> Or help them on to better days.

In more than one respect were Goethe and Saint-Simon ideological contemporaries, both original and independent of, yet in agreement with, each other.

It is noteworthy that beginning with sociology as a positive science of the near future Saint-Simon ends with the problem of the unification of particular sciences and vice-versa starting from an idea of general science he extends it to include socio-ethical norms; thus the dividing line between sociology and general science is somewhat blurred; both overlap to a degree that at times they become indistinguishable from each other.

In the last period of his life (1820–1825) Saint-Simon sobered to speak of "generalities of human knowledges" in the plural instead of "general science" in the singular. This gave a realistic turn to his conception; for such general groups of sciences began to crystallize at that time as the first stage of a unification of science: partial gen-

eralizations formed together with a classification or reclassification in the realm of science.

Obviously, "Humanities," "Moral Sciences," "Philosophy" etc. are included among those general disciplines, as Saint-Simon reasons in "The New Christianity" (1825): "Our ancestors of the Middle Ages had made a mistake of underrating the usefulness of a study of particular facts and secondary principles as well as an analysis of private interests." . . . "Yet it is equally true that a great evil resulted for the community from the abandonment, since the Fifteenth Century, of works devoted to the study of general principles and general interests.* This abandonment gave birth to a feeling of selfishness which became predominant in all classes and all individuals."

It is seen that even in his last period Saint-Simon persists in attributing a socio-ethical function to the learning concerned with "the generalities of human knowledges," which certainly goes beyond epistemological preoccupations. However, *at that time, in contradistinction to the suggestions of the first period, foundations of ethics were affirmed by him independently of science in an autonomous and even absolute manner through religious channels. Thus a coördination of science with ethics became a necessity for Saint-Simon and was declared by him to be imperative.*

3. The last phase of Saint-Simon's doctrine (about 1817–1825) can briefly be formulated as that of the organization of society on the basis of "positive science"† and especially *scientific technology* for "the great purpose of improving the moral and physical conditions of the poor classes," in Saint-Simon's own words.

According to Saint-Simon the Christian ethics of brotherly love makes it mandatory to improve the moral and physical conditions of the people, the latter principle being in content identical with the former yet better adapted to the aspects of our civilization.

Saint-Simon attached to the supreme principle of Christian ethics also a function of unifying or integrating the sciences, as for example, he says: "As for persons . . . who . . . could doubt the superhuman excellence of the Christian principle they should at least respect it as the most general principle that mankind has ever employed, likewise as the most elevated theory ever produced in the course of eighteen centuries" (From the Preface to "The New Christianity" (1825)) and then he elaborates this point in the body of this work:

"Man's intellectual forces are very small; it is only by making them converge toward a single objective . . . that one can succeed in producing a great effect and obtain an important result"; and further:

"The adoption of the new Christianity will accelerate the progress of civilization infinitely more than any other general measure, by making the works relative to the generalities of knowledges and those concerned with the improvement of specialties proceed all abreast." . . .

Again: "There is one science much more important for society than physical and mathematical knowledges: this is that which serves as its foundation; its morals."

*An obvious overstatement since that study was not discontinued by philosophers and scientists.

†With Saint-Simon this means "science based on positive demonstrations, that is observations." An unusually strong emphasis laid by Saint-Simon on industrialization goes together at that time with the tremendous technological progress already referred to.

Saint-Simon wrote his last important works: "On the Industrial System" (1821) and "The New Christianity" (1825) at the time of "the appalling prolongation of the crisis and terrible thunderstorms (*orages terribles*) by which it has been accompanied." There he expressly put it forth that *only the scientific industrialization of society inspired by and coördinated with the ideals of social humanism could bring to an end the crisis and stabilize moral and social conditions of mankind.*

We refer the reader to the characteristics (1) and (2) of the evolutionary and semi-stabilized period of the nineteenth century as sketched in the introductory part of this paper and let him decide for himself whether Goethe and Saint-Simon had any vision of things to come, at least of some of them.

Shall history repeat at the *present* time "the appalling prolongation of the crisis and terrible thunderstorms that have accompanied it"?

4. In the last period of their lives both Goethe and Saint-Simon asserted the broadened humanism in an absolute manner by way of religion, that is Christianity; the nonpolitical character of their humanism is a corollary to its ethical absolutism. It has been questioned whether the affirmation was essentially religious or only formally so. Yet the writer entertains no doubt about that it was *"essential" but neither theological nor canonical.* This is especially true of Saint-Simon. It has already been mentioned that Saint-Simon laid emphasis on a social aspect of modern humanism; this was in agreement with his general and perpetual preoccupation with the problem of social organization.

First, he had avowedly and in a straightforward manner advocated the creation of a new science of social organization ("sociology" in the later terminology) and a unification of sciences to that effect. Disappointed in that the realization of his expectations was not coming fast enough he turned to Christian ethics, interpreted it pointedly as an ethics of social norms in contradistinction to norms for the individual and, what was as important, he advanced the argument that this ethics should be coördinated with a scientific industrialization of society and development of both "particular" and "general" sciences and *vice versa,* thus trying to implement ethics and science one with the other.

Both Goethe and Saint-Simon had heralded the advent of a richer type of humanism—composite and integral—that later underlay to an extent the development of nineteenth century society. Both were aware of *the inner antinomy of the new humanism* * *and sought its resolution in action* coördinated with the absolute ethics of brotherly love for man, on the one hand, and implemented with science—especially with *scientific technology, conceived as science for and of action—on the other.*

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* This was one of the favorite themes of Ibsen, Dostoevski and others in the second half of the nineteenth century.

Improving the Mathematics Preparation for Specializing in Technical and Scientific Fields

By NOAH R. BRYAN
University of Maine

Introductory Note.—The pendulum has swung too far in American high schools in allowing students to pick and choose their courses as they wish. Educators and parents now realize the serious lack of knowledge of mathematics on the part of many of its young men and women who are in war service. Professor Bryan's plan will provide a well organized program for overcoming these deficiencies and shortcomings in present day high-school programs in mathematics.—Dean Paul Cloke, College of Technology, University of Maine.

There is a *weakness in the training in mathematics* for students who take technical and scientific courses. Much of this weakness can be eliminated by improving the mathematics preparation during the period from the completion of second-year high-school algebra to the end of the first year of college mathematics. Such an improvement will then enable students to take a satisfactory course in differential equations in their sophomore year at college. It is the principal purpose of this article to show how the training in mathematics for the period mentioned may be improved. In order to accomplish this objective there must be a revision of the mathematics curricula for this period. Along with the discussion of such revision, suggestions will be given on the presentation of subject matter.*

Before beginning the discussion on the revision of mathematics curricula, some picture of the background will be given to aid in understanding more fully the value of the changes suggested.

In the period of reconstruction and expansion after this global war, *there will be greater and greater need of specialists with sufficient training in mathematics* in industrial, technical, and scientific fields. World competition will be decidedly more pronounced. The leaders in these various fields in Great Britain are already projecting their plans for the first decade after the cessation of hostilities. For American firms to meet world competition, the number of specialists trained in mathematics must be greatly increased. College students in technical and scientific fields come under the heading of potential specialists and their earlier training

*For the more detailed discussion upon which this article is based, see a study: Reorganization of Mathematics Curricula in Liberal Arts Colleges, by Noah R. Bryan, University of Maine. A copy of this study is on file in the Library of Congress, Accessions Division, Washington, D. C. (My colleagues, Doctors Kimball and Kales, gave me valuable criticisms and suggestions in the preparation of this study.) This study is hereinafter referred to as Reorg. Curric.

in mathematics must be planned with their future fields in mind.

According to a recent radio broadcast, Germany, because she is hoping for a negotiated peace, is already earmarking promising boys from six to sixteen years for scientific training in preparation for the next war for world conquest.

From time to time mathematicians and specialists have used their influence to introduce changes in mathematics curricula to make the training in mathematics more efficient for the conditions then existing. In the latter part of the eighteenth century, the French mathematician Lagrange organized the mathematics curricula of the École Polytechnique. A comparative study of mathematics curricula of a number of countries by a committee working under the sponsorship of the Mathematics Association of America (c. 1920) found that our college freshmen taking technical courses were not nearly so well-prepared in mathematics as corresponding students in Great Britain, France, Germany, and Russia.

That more specialists with sufficient training in mathematics are needed is shown also by the increase in research in the field of applied mathematics. An illustration of interest in this type of research is shown by the Program of Advanced Instruction and Research in Mechanics at Brown University. In their pamphlet of information about this research project, we find in a report by an Evaluating Committee a statement to the effect that *emphasis on applied mathematics should be approximately equal to that placed on pure mathematics.*

Relative to college freshmen in mathematics, it can be said with little or no contradiction that they *lack facility in the use of mathematical language.* This weakness can be overcome by introducing earlier mathematical terms which will add greatly to the meaning of the discussion of a topic; as, for example, finding maximum or minimum values of a quadratic function. Likewise, *the grouping of topics by virtue of their mutual relationships makes possible and desirable the earlier introduction of certain mathematical terms,* as, in connection with the plotting of the equations of the circle, parabola, ellipse, and hyperbola. In the discussion on the revision of mathematics curricula later in this article, it will be shown how the grouping of topics by virtue of their mutual relationships may be carried out. By this means the student will receive training in the fundamentals of the kind of mathematics that he will study in later courses. This training will establish correct habits of mathematical thinking and *a student's mathematical knowledge will become a part of his experience.* Laboratory methods may be used to indicate why a theorem or a formula holds where the theoretical method of proof is too difficult; as, to show in the more elementary work that the sum of the interior angles of a triangle equals 180°. Furthermore, the mathematical training indicated makes it possible for the student to become *familiar in easy stages with the material of mathematics* used in the later more difficult work.

The proposed mathematics curricula shows more clearly the continuity in the development of the subject matter. The student becomes conscious that the work is progressive—that it is leading somewhere. *The interest of the student is aroused by this long-range planning with the definite objective of laying a foundation in the kind of mathematics essential to a satisfactory pursuit of technical and scientific*

courses. This challenge to students of ability gives zest to their efforts. The students will feel that their training in mathematics is worth while.

The new C.E.E.B. examinations which test levels of achievement in mathematics make the proposed revised curricula possible.

It is the trend today to begin earlier the specialized training of students who are going to take technical and scientific courses. Current reading shows that this is especially true with regard to the training in mathematics of students who intend to enter technical and scientific fields. In order to discover early young people who may have special ability in physics, New York City has established the Bronx High School of Science. I quote a statement from Principal Meister: "The school seems to be meeting an important need, since about 2,000 students apply each year. We can admit only about 500 a year." Also, an analogous project is being carried on by Westinghouse. I quote: "The Science Talent Search is a systematic attempt to discover potential scientists while they are still in high school, and to help them complete their education. It is sponsored by Westinghouse and conducted by Science Clubs of America." * At this place it might be well to point out also that the subject matter in the proposed revised mathematics curricula for the precollege period is not new material with the exception of the geometric propositions to be proved by coördinate methods. Approximately all such subject matter was included in a course in intermediate algebra in the Pennsylvania high schools during the second decade of the present century. Today many more secondary schools include approximately all of such subject matter in their curricula. In other schools the proposed changes can perhaps be made more readily if the work is directed and supervised by some sponsoring organization such as a college in the vicinity.

The phase of mathematics considered in the *proposed revised curricula* extends from the completion of second-year algebra through one year of college mathematics. Many of the topics selected are those which teaching experience has shown that students must know in their study of calculus and the development of *introductory* calculus in this proposed plan is in keeping with the modern way of beginning that subject.

The subject matter here indicated is no more difficult than that which is now included in the period covered and it deals with topics that are directly of value in later mathematics both because of knowledge imparted and because of training furnished. The *test as to whether a student knows some newly presented subject matter is his ability to use it in later topics in mathematics.* Many of these topics which will test his knowledge follow almost immediately in the proposed curriculum. This type of development contributes much toward maintaining continuity in the development of the subject matter. The exercises are largely mathematical in character and are designed to aid the student to get a mastery of the subject matter just presented. Applied exercises are desirable also but should in general be such that the student will not be uncertain of conditions involved because of his lack of understanding of the technical nature of the applied exercises. It is the obligation of the teacher to put the emphasis on the theory of the mathematics involved.

* *National Geographic Magazine,* December, 1943, p. v.

The student gets the applications in the various applied courses which he may take. If a student has difficulty with techniques which he should have learned in the preceding courses, then the individual student should review such techniques on his own responsibility until he has mastered them. In this way the class as a whole will not be held up in the learning of new subject matter. Home work should be assigned but each student should be responsible for learning it. Instead of handing the home work in, difficulties that have been encountered should be cleared up in the recitation period. Whether the class has a mastery of the day's assignment should be ascertained by a brief daily test on paper or at the board. For a general knowledge of the subject matter there should be frequent longer tests. Second-year algebra should be completed by the end of the tenth school year. The mathematics for the next three years may be arranged according to the following plan.

Eleventh School-Year Mathematics:

Systems of equations of the first degree, including graphic methods featuring relationships between analytic geometry and algebra as illustrated by the relative positions of two straight lines in a plane and the equations representing these lines. Slope of a line. Slope-intercept formula of a straight line. Conditions for parallelism and perpendicularity.

Second order determinants as developed in connection with the discussion of the relative positions of two straight lines in a plane.

Determinants of the third order. Inequalities including their graphic representation.

Quadratic equations and the graphic representation of quadratic functions. Analytic method of finding a maximum or minimum value of a quadratic function of the type $y = ax^2 + bx + c$. Nature of roots shown graphically. Derivation by application of the binomial theorem of the rule for finding the derivative of ax^n; finding maxima and minima values by use of the derivative. Quadratic inequalities represented graphically.

Graphic representation of conic sections. A student should be given training to recognize certain type equations. This will make it possible for him to plot such equations easily. It will also make his algebra more interesting. Circle, ellipse, hyperbola. (Parabola already discussed under quadratic functions.)

General equation of the second degree. Formula for $\tan 2\theta$, where θ represents the inclination of the axes. Determinant form of the discriminant of an equation of the second degree. Criteria for types of conics. Elimination of an xy-term. Trigonometry introduced as needed.

Note.—The topics under the general equation of second degree necessitate a type of application of algebra which furnishes highly desirable training in that it is an application of algebra in the development of new topics in mathematics, and reviews the kind of algebra that contributes to success in the later work in mathematics. The subject matter thus far has covered a large part of plane analytic geometry and eliminates the need of a separate course in that subject. Additional topics in plane and solid analytic geometry can be more effectively taught in calculus as the need arises.

Graphic solutions of pairs of equations in connection with their algebraic solutions. If at least one of a pair of equations is of the second degree then

their graphic representation shows clearly the number of pairs of values that will satisfy the conditions. Also *this systematic training in analytic geometry is what a student needs to understand readily additional work in that subject and work in calculus.*

Additional topics in introductory trigonometry. See Reorg. Curric., pp. 52–59.

Proofs of certain geometric propositions by coördinate methods. See Reorg. Curric., pp. 59–65.

The mathematics of the first half of the twelfth school year consists of the proofs in the customary manner of such geometric propositions as are required by the C.E.E.B. The proofs of certain propositions from solid geometry should be discussed in connection with their associated proofs in plane geometry. The additional factual knowledge of geometric relationships in plane and solid geometry should be acquired by means of exercises.

The mathematics of the second half of the twelfth school year covers the differentiation and integration of algebraic polynomials. (Professor Stoney * after years of experience in teaching in London Technical Schools said that he was convinced that boys should begin their acquaintance with calculus early in order that the ideas of calculus might become a part of their experience.)

The first half of first-year college mathematics consists of a course in algebra beginning with theory of equations and extending through complex numbers and a standard course in trigonometry.

The latter half of the first year of college mathematics should complete differential and integral calculus.

Note.—Time wasted in long methods of calculation should be reduced to a minimum by the use of calculating machines, slide rules and tables. Radicals can be changed to approximate decimals. In this way there will be more time for productive thinking.

* John Stoney, "An Introduction to Differential and Integral Calculus." Preface. "Fortunately, the calculus is now being taught to boys of fifteen or sixteen in day and evening technical schools, and it will grow up with them in the same way as their trigonometry and arithmetic have done."

Problems of Signal Corps War Training Program in Communications*

By PAUL G. ANDRES

Associate Professor of Electrical Engineering, Supervisor of Training and Instruction, Signal Corps Training Program, Illinois Institute of Technology

Since the initiation slightly more than a year ago of Signal Corps Training Courses at the Illinois Institute of Technology, a total of 1,859 students were graduated from a twelve-week course as Radio Technicians and Mechanics (Pre-Radar), 675 from a ten-week Advanced Electronics and Radio Course, and 416 from a ten-week course in Ultra High Frequency Techniques. At the present time, there are about 800 students in these three courses, and this figure is approximately correct for the number of students in these courses at any one time during the past year. Pre-Radar is a contract course; the two advanced courses are operated under the Engineering, Science, and Management War Training Program of the United States Department of Education.

In the development of a suitable curriculum, the obtaining of an instructional and supervisory staff, and the procurement of facilities, numerous problems were encountered. The present paper concerns itself with some of the problems associated with the Training Program as far as the entire Signal Corps Training curriculum and staff are concerned, and in particular with the Pre-Radar division.

The purpose of the Pre-Radar curriculum is to provide the students with a basic theoretical background in electricity and both theoretical and practical work in radio, thereby equipping the men for radio field work in the Army or for other specialized and advanced training in radio or electronics, such as our Advanced Electronics and Radio Course or the Army Radar Course. The general nature of the curriculum was thus predetermined, and the problem became a pedagogical one: specifically, what material satisfying the stated objective could be effectively assimilated by the students and how should it be presented? The potential students, selected on a basis either of previous educational training or of industrial service in the field of electrical engineering or communications, together with a high score in the general Army classification test, possessed variegated backgrounds. Without some mathematical knowledge, a satisfactory level of attainment cannot be achieved in the work in radio and electricity, for of all the engineering fields electrical engineering is most dependent upon mathematics. Consequently, it was necessary to include mathematics as well as electricity and

* Presented at the Fiftieth Anniversary meeting, S.P.E.E., Chicago, Illinois, June 18-20, 1943.

radio in the curriculum. In the Pre-Radar course, for example, algebra is necessary in determining the equivalent resistance of a combination and in the solution of equations based on Kirchhoff's laws; trigonometry, the J operator, and simple vector algebra are only a few of the mathematical tools needed in understanding alternating current circuits and resonance. In the advanced courses, calculus and differential equations are essential for the study of electronics; Fourier series, vector analysis, and more advanced mathematics are important in wave radiation and propagation and in high frequency techniques. It is apparent that the introduction of mathematics in the curriculum was inevitable. After the inclusion of mathematics in the Pre-Radar course, we found that the solution of electrical problems was considerably expedited, for the student had acquired facility with a necessary tool and had solved analogous problems in his study of mathematics. Moreover, mathematical rigor helped the student to think logically and clearly.

In general, all three courses are divided into an eight-hour day. The electronics and ultra high frequency techniques students consisting of classes in the neighborhood of 100 are each carried through their courses as a group. In the twelve-week Pre-Radar course, between 200 and 250 students start and finish every four weeks. This provides us then with three groups at various stages of development in the Pre-Radar course and two unit groups in the more advanced courses.

Pre-Radar Student Background

These students are selected by the Signal Corps on the basis of various examinations. In order to develop the curriculum so as to apply the course of study to the particular needs of the students from the standpoint of mathematics, an analysis is made of every incoming group as to their age, their

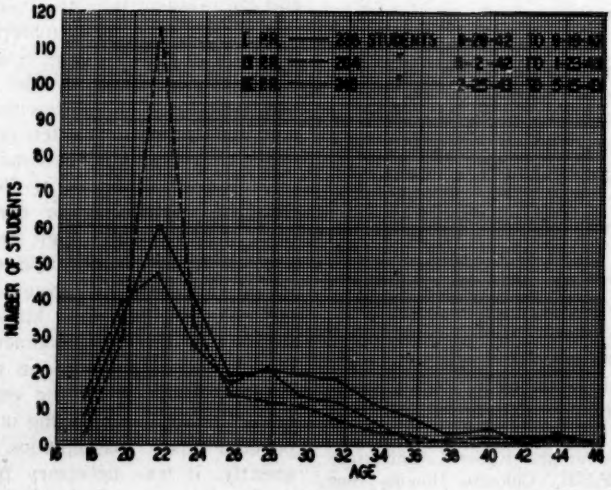


Fig. 1

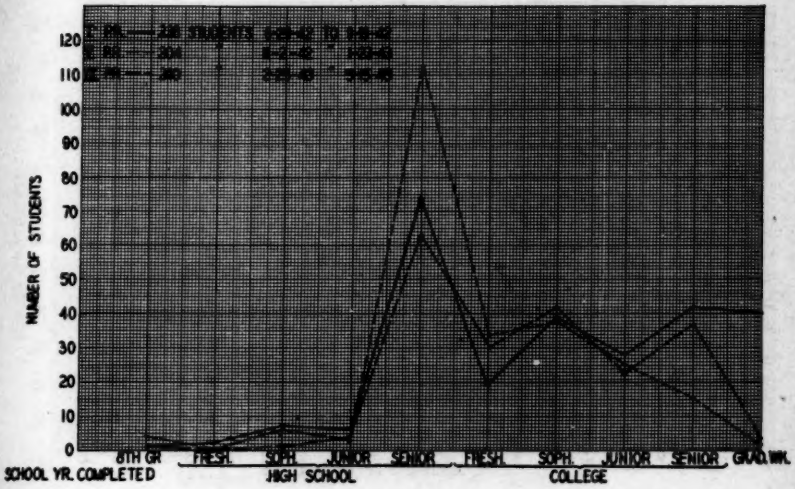


FIG. 2

previous educational background, and, in particular, the number of semesters of mathematics they have covered and their industrial or radio experience.

Figure 1 shows the age of 682 students representing the first, an intermediate, and a group which has just completed the course. The ages range from 17 years to 45, with a high percentage in the range between 19 and 25. There is a peak in the curve showing the greatest number of students between 21 and 22 years of age. The records of these same students show that the majority of them were seniors or had completed high school as shown in Fig. 2, and a substantial percentage were college students or had completed their college work. It may be stated parenthetically that a number of these college students were not students in engineering but took courses in liberal arts, mathematics, science, or other subjects. Figure 3 shows the number of semesters of mathematics of these students. The peaks of high school or college studies in mathematics are disclosed at four and seven semesters of mathematics. Figure 4 shows the previous training and experience of Pre-Radar students. Of the 682 students, less than 25 per cent have had a year or more of industrial experience, less than 10 per cent have had five years or more, and only 3 per cent have had ten years or more, but approximately 31 per cent did have six months and about 6 per cent had three months of previous Signal Corps Training. It is interesting to note at this point that of the total number of students, 108 had made radio their hobby.

The variety of backgrounds indicated by these figures suggested the need for orientation tests and the possibility of sectioning these men in accordance with their backgrounds. Orientation examinations in electrical and radio theory and in mathematics were given to each student. The mathemat-

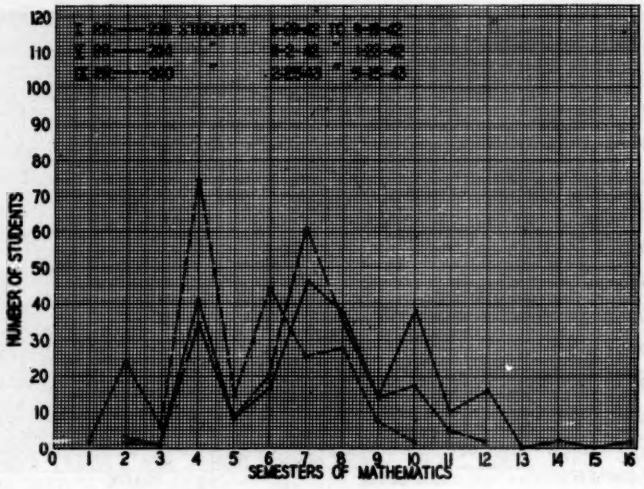


FIG. 3

ics examination covered elementary problems in algebra, trigonometry, analytic geometry, and calculus. It was simple in nature and anyone with previous exposure should have received a reasonably good mark. Figure 5 provides us with a graph showing the grades scored in orientation examinations in mathematics. It will be noted that the curve is very irregular and in a measure may be correlated with the number of semesters of mathematics which the student has as a background as shown in Fig. 3. Similarly, the examination in electrical and radio theory dealt with simple and factual topics. This curve (Fig. 6), more peak-free than the other, indicates a greater uniformity, and this uniformity may be attributed to previous training or an interest in electrical and radio subjects. On the basis of the foregoing information and the desired results to be achieved in training these men for further study or specialized training on the part of the Army, a curriculum was developed in electrical and radio theory as well as one in mathematics.

Previous Training and Experience of Pre-Radar Students	
Total students	682
Industrial Experience	
1 Year or more	152
5 Years or more	67
10 Years or more	21
Previous Signal Corps Training	
3 Months	39
6 Months	213
Radio as a hobby	108

FIG. 4

CURRICULUM

Advanced studies in electronics and radio require a basic engineering background of the fundamentals of electrical theory and of radio. Visits to Signal Corps Training Schools at Fort Monmouth and Camp Crowder disclosed the fact that the students who may be assigned to such training cen-

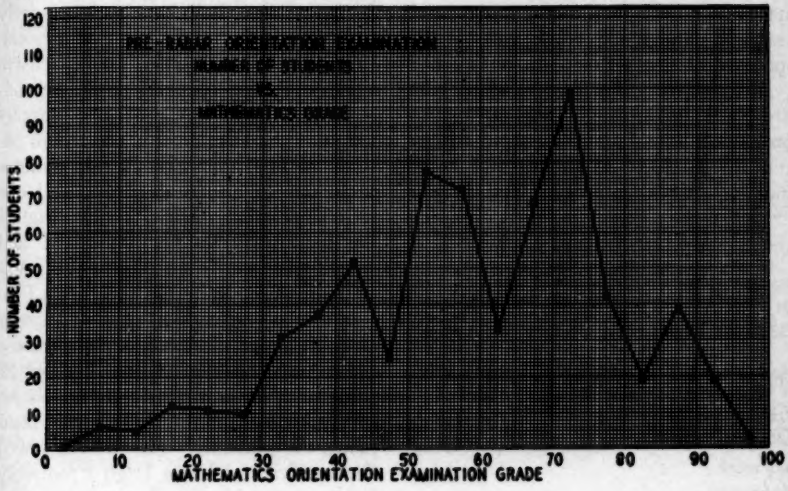


FIG. 5

ters require a basic practical knowledge. Since these training centers are set up on a project basis, any entering student may by-pass certain courses by successfully taking examinations and proceed to the study of specialized Army equipment.

A program of electrical and radio

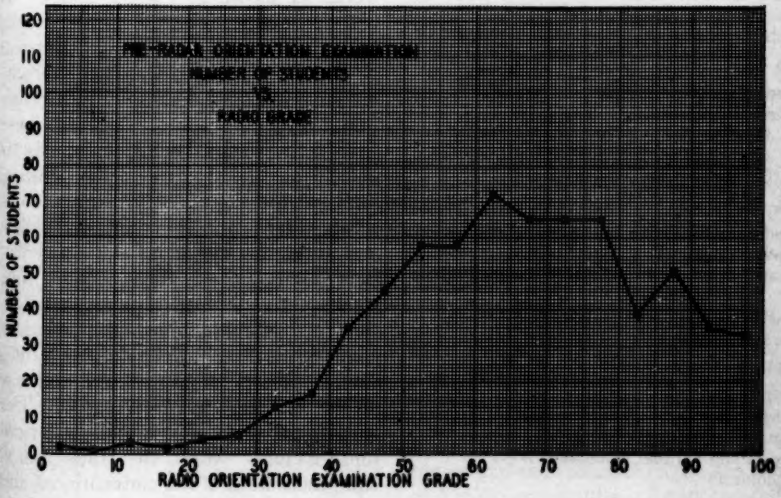


FIG. 6

theory, the necessary mathematics, and practical laboratory work was developed. Utilizing an eight-hour day and a six-day week each student in the Pre-Radar group has a formal lecture demonstration of one hour and fifteen minutes in electrical theory and radio and one in mathematics. The lecture demonstration hall has been properly equipped with public address system, well lighted blackboard, and extensive equipment for experimental demonstrations. The lectures are supplemented by conference or classroom periods of one hour and fifteen minutes each, one in electrical theory and one in mathematics. Here the material of the lecture is further discussed and amplified in accordance with the needs of the group. Whereas the entire Pre-Radar class attends a lecture demonstration, approximately 200 students, the conferences are limited to about 25 students. In addition, a daily laboratory period of about three hours completes the schedule. (In the Advanced Electronics and Ultra High Frequency Courses, the schedule deviates from the above in that the time required for mathematics lectures and conferences is somewhat less.)

Pre-Radar Training Course

Communication Topics

1st week

Electrical fundamentals; series and parallel circuits
Measurement of resistance; power and energy
Primary and secondary cells
Kirchhoff's Laws

2nd week

Magnetism
Magnetic circuits
Inductance and capacitance
Alternating currents
Reactance

3rd week

Impedance
Series and Parallel A. C. Circuits
Tube characteristics—diodes and triodes
Vacuum tube developments
Tube classifications—equivalent circuits

4th week

Power supplies
Three stage receiver
D. C. generator
D. C. motors
A. C.; three phase systems

5th week

Audio amplifiers
Audio amplifiers
Transformer and impedance coupled audio amplifiers
Push-pull amplifiers and phase inverters
Inverse feedback

6th week

The decibel
Rectification and detection, diodes, crystals
Automatic volume control
Series and parallel resonance
Oscillators

FIG. 7

The twelve-week curriculum in electricity and radio developed on this basis was broken down into individual weeks as shown in Figs. 7 and 8. It will be noted that the first four weeks are primarily concerned with electrical physics, a study of direct and alternating current principles, and an introduction to vacuum tubes. During these first four weeks, much emphasis is placed on the lecture demonstration method; for example, the students observe alternating current principles, and tube characteristics on a twenty-inch oscilloscope. The second four weeks are concerned with the application of vacuum tubes, amplification, and rectification. Considerable attention is placed on the theory and use of the cathode ray oscilloscope. The final four weeks of the radio curriculum include work in transmission equipment both of the conventional and ultra high frequency type, an introduc-

tion to wave propagation, and antenna systems. Frequency modulated transmitters and receivers are given some attention.

As mentioned previously, concurrent with the radio lectures and conferences

Pre-Radar Training Course

Communication Topics

7th week

The superheterodyne receiver
The superhet, pentagrid converter and mixer tubes
Cathode ray oscilloscope
Cathode ray oscilloscope
Application of cathode ray oscilloscope

8th week

D. C. power supplies, doublers, regular tubes
Vibrator power supplies
Triode detectors
Vacuum tube voltmeters
Electronic vacuum tube voltmeters

9th week

Oscillators, multivibrators and negative transconductance
Class A, B and C RF amplifiers
Class A, B and C RF amplifiers
Class A, B and C RF amplifiers
Radio transmission and amplitude modulation

10th week

The buffer amplifier and modulated amplifier
Plate modulation
Transmitter power supplies and overload relays
Complete transmitters—operation and adjustment
H. F. oscillators, klystron, magnetron, etc.

11 week

Electromagnetic waves
Radio wave propagation
Transmission lines
Antenna systems
Directional antenna systems

12th week

Special antenna systems
Frequency modulation
F. M. transmitters
F. M. receivers
Wave filters

FIG. 8

Pre-Radar Training Course

Mathematics Topics

1st week

Exponents, polynomials, factoring
Fractions, exponents, radicals
Functions and graphs

2nd week

Linear equations; systems and graphs
Scientific notation, significant digits, accuracy
Angles: the coördinate systems, trigonometric functions
Functions of special angles: radians, periodic functions

3rd week

Radians and periodic functions
Inverse trigonometric functions, trigonometric tables
Right triangles, vectors
Logarithms (theory)

4th week

Logarithms
  Use of tables, computations
  Equations, graphs
Trigonometric functions
  Fundamental identities
  Operations and identities

5th week

Factor theorem
Binomial theorem
Quadratic equations
  Graphs: factor solutions
  Formula
  Special forms: systems

6th week

Equations of higher degree
Determinants
Functions of multiple angles
Double and half angles
Sums and differences of functions

FIG. 9

there are lectures and conference periods in mathematics. The twelve-week mathematics curriculum is outlined in Figs. 9 and 10 broken down by weeks. As far as possible, there is correlation between the mathematics topics and the material in the electrical and radio curriculum. Fundamentally,

Pre-Radar Training Course
Mathematics Topics

7th week

Trigonometric identities and equations
Law of sines
Law of cosines
Complex numbers

8th week

Analytic geometry
- Distance, midpoint
- Slope
- The straight line: point slope: two-point forms; slope intercept; intercept form

9th week

Analytic geometry
- General linear equation
- Normal form
- Distance, line to point
- Circle

10th week

Analytic geometry
- Parabola
- Ellipse
- Hyperbola

11th week

Analytic geometry
- General forms of equations
- Polar coördinates and curves
- Relationships between polar and rectangular coördinates

Introduction to differential calculus

12 week

Calculus
- Differentiation
- Differentiation formulas
- Implicit differentiation
- Successive differentiation
- Applications of the derivative

FIG. 10

the mode of approach is to present and use mathematics as a tool and to inject as much rigor and development as time permits. Figures 9 and 10 reveal the survey nature of the mathematics course; topics from elementary and college algebra, trigonometry, analytic geometry, and calculus receive consideration. In general, those topics were chosen for their immediate applicability in the electrical and radio program and as preparation for advanced work. By limiting the topics from each of these fields of mathematics, the essential subject matter was presented without a sacrifice of rigor maintained in college freshman and sophomore mathematical courses. It may be seen that trigonometry appears in the second week and again in the seventh; algebra in the first and in the fifth. The reason for this is that the complexity of the problems involved and the concepts required are correlated with phases of the radio work. For instance, in the second week trigonometry appears in the mathematics curriculum because it is required for an understanding of the principles of alternating current in the second week of the communications course. Later, more advanced phases of trigonometry are required in the program, and they are then studied.

Figure 11 shows the average radio theory grade for the twelve weeks. It will be noted that the radio grades are consistently high and follow a more or less uniform pattern in the upper bracket. It is interesting to compare this curve with the previous orientation curve in radio (Fig. 6), keeping in mind that the orientation curve is based on simple and elementary questions and that the average radio theory grade is based on the curriculum as given. Even with this difference in mind, the second curve shows a considerable assimilation of the basic theory on the part of the student.

In the case of the average mathematics grades shown by Fig. 12, there has also been an upgrading and a levelling as compared with the elementary orientation examination results shown in Fig. 5, and the peaks in the latter curve have been substantially reduced or

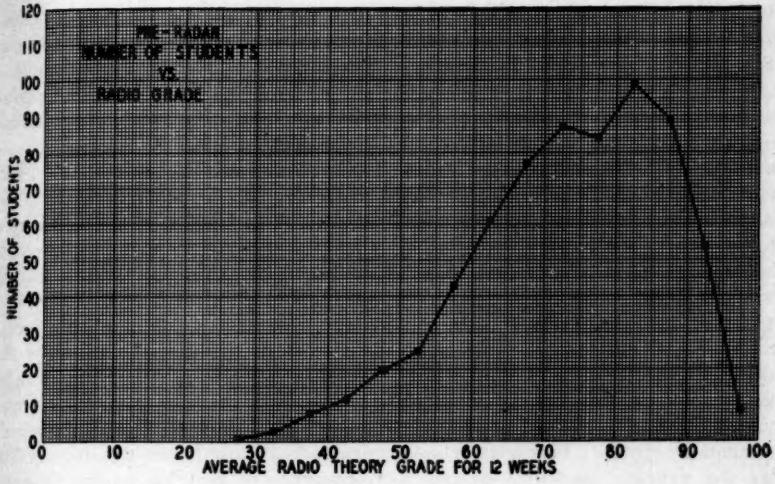


FIG. 11

eliminated. It must be kept in mind that a strict comparison between the orientation examination and the final grades cannot be made because the subjects taught are of college freshman and sophomore level to which a greater percentage of the students have never been exposed. In other words, the final student product is more nearly uniform and is on a consistently higher level, somewhat independent of previous training. For those students

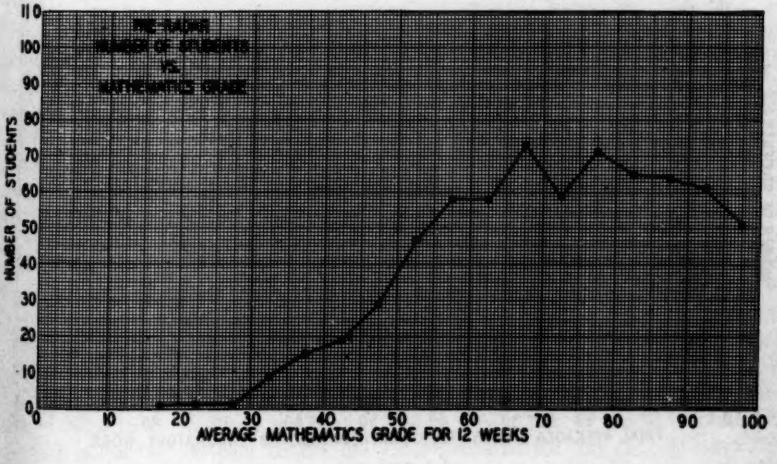


FIG. 12

who have had previous training in physics and mathematics, the early weeks of the course serve as a necessary review, and in the final analysis the students, irrespective of their backgrounds, approach a more nearly common level. The overall average radio, mathematics, and laboratory grades are shown in Fig. 13 which represents approximately the normal distribution curve which could be expected from a group of freshman and sophomore college students. That there is some correlation between the mathematics training and the electrical and radio training may be inferred from Fig. 14 on which the radio grade is plotted against the mathematics grade. This curve shows that the average student who has a given grade in radio has a corresponding grade in mathematics. The mathematical nature of courses in electricity already mentioned precludes the possibility of satisfactory work in electricity or radio without correspondingly satisfactory work in mathematics, and our early experience in the Pre-Radar program demonstrated clearly the necessity and value of correlating mathematics and electricity.

In view of the diversified backgrounds of the students, the curriculum had to be of such a nature as to train the students with poor backgrounds without impeding the better trained men. Figure 15 is an indication that this can be accomplished in some measure. Here the two curves show the average weekly achievement in radio of men with previous training in trigonometry or more advanced mathematics and of those below this level. The proximity of the two curves suggests that the men with little mathematical background are able to assimilate the material; yet the grades obtained by the men having had more mathematics indicate that the entire curriculum de-

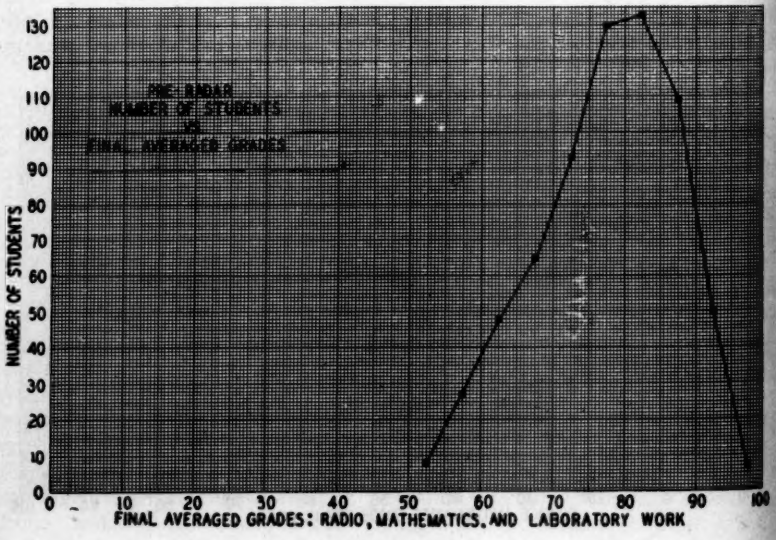


FIG. 13

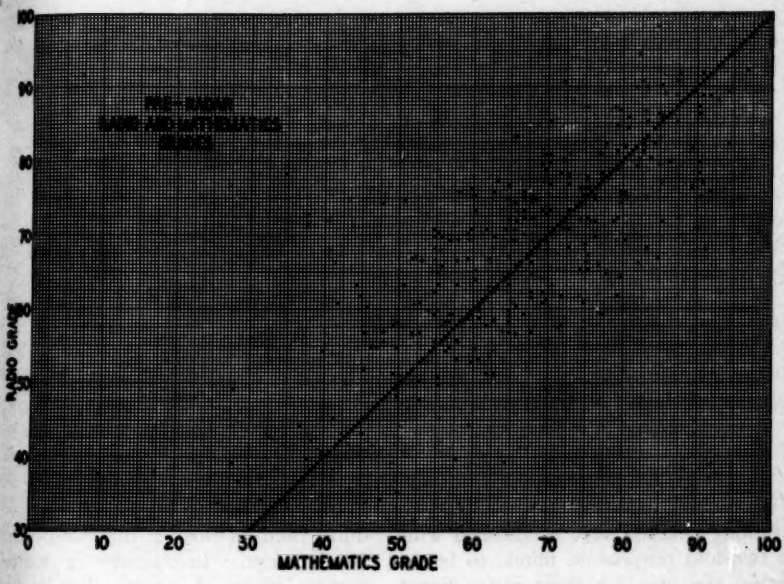


FIG. 14

mands the best attention of students irrespective of their previous training.

STAFF PROBLEMS

The acquisition of an engineering and mathematics staff in Wartime is an obvious difficulty. Figure 16 indicates roughly the type of men we obtained for the Pre-Radar and the advanced courses. Mathematicians and electrical or radio engineers were needed. Of the fifty-six instructors in both sections, all had Bachelor's degrees. About 43 per cent had the Master's Degree and 12 per cent the Doctorate. Twenty-nine instructors had degrees in mathematics, twenty-one in electrical engineering, and six in physics. One year or more of industrial experience was had by 37 per cent and about 34 per cent of the instructors had a year or more of teaching experience in high schools while approximately another 34 per cent had a year or more of college or university experience.

The permanent staffing of a college with such an aggregate of men would be questionable. But for a Training Program like Pre-Radar, the aptitude and flexibility of the instructors are as vital as their scholarly attainment. Good men with excellent undergraduate backgrounds in the sciences or engineering and with interest and enthusiasm have been used very effectively in such a curriculum. In our experience with the Training Program, the practical aptitude, the association with men having advanced training and the interest in contributing to the War effort on the part of the instructors has compensated for any lack of advanced training. Beyond this, special staff

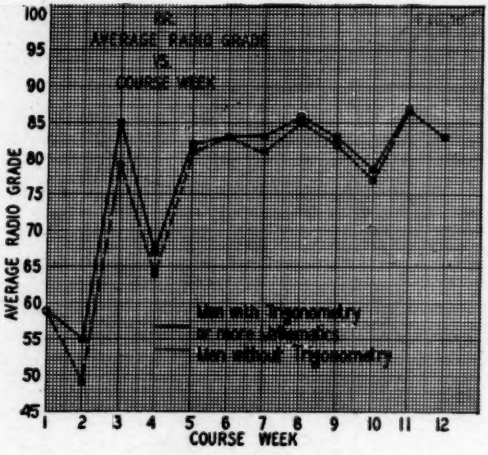


FIG. 15

training courses were established with a two-fold purpose in mind: to better equip the men for their instructional duties and to further their individual development. Instructors in mathematics, many of whom already had some training in electricity and radio, and, for the purposes of review, instructors in radio were given radio courses. An elementary course covered the entire theoretical and laboratory work of the Pre-Radar curriculum, giving the instructors a thorough knowledge of the theoretical, experimental and practical features of the Training Program. Advanced courses in radio, electricity, electronics, and ultra high frequency were established. Training of the instructors as well as the Signal Corps Training Program was under the direction and supervision of the Electrical Engineering Department of the Illinois Institute of Technology.

The schedule of the staff coincides with that of the students: eight hours a day, six days a week. A typical daily assignment includes the holding of two conferences in the morning and a laboratory in the afternoon. Where the

Staff Background

	Pre-Radar	Adv. Electronics and Ultra High Frequency
Total number of instructors	37	19
Educational Attainment		
B.S., B.A. or higher	37	19
M.S., M.A., or higher	15	9
Ph.D	4	3
Industrial Experience		
1 year or more	14	7
5 years or more	9	4
10 years or more	3	3
Previous Teaching Experience		
High School		
1 year or more	18	1
5 years or more	4	
10 years or more	2	
College		
1 year or more	14	5
5 years or more	11	4
10 years or more	7	2

FIG. 16

load is lighter than this, supervisory work, preparation of examinations, or the building of equipment augments the instructor's duties. The schedule is exacting and necessitates a definite esprit de corps among both instructors and students.

Conclusion

With the job of the Pre-Radar Training Program in mind, a satisfactory curriculum must include training in the fundamentals of electricity, in radio, and in mathematics, supplemented by experimental and practical work in the laboratory. A twelve-week program like the Pre-Radar necessitates a rigorous daily schedule both for students and staff. Finally, a staff training program must be developed.

The author wishes to express his thanks to the members of the training staff who are working long hours in contributing their bit to our common War effort, to the supervisors who are responsible for much of the planning of the curriculum and carrying out the program, and in particular to Dr. J. E. Hobson, Director of the Department of Electrical Engineering and of the Signal Corps Training Program, for his guidance in the development and smooth operation of the program.

Social Science in the Engineering College

By FRANK T. CARLTON
Case School of Applied Science

In the education of engineers the place of economics and other subjects in the humanities group will ultimately be determined by the scope of the functions which are to be performed by the engineer of today and tomorrow. The goal of the engineering college should be definitely outlined. Unfortunately, members of the faculties of our engineering colleges do not today agree as to the aims of the institution, or as to the desirability of different subjects, or combination of subjects. If the engineer is to be a skilled craftsman or an expert in the research laboratory, it may be argued that he will require very little work in the humanities. His education should be chiefly, if not solely, vocational. If, however, the engineer is destined to be the director of the great and complex production machinery of the nation, a very different conclusion may be reached.

Today, in the United States, we have a magnificent production machine, built and directed by scientists, engineers, and skilled workers. Our chief difficulties are with the distribution of and the demand for the products of this great technological organization, with the financial side, rather than the technical side, of the United States considered to be a gigantic factory or plantation. The continuous and efficient functioning of industry is now vitally important to all. In pioneer days the significant matter was the proper functioning of each little economic unit and each local market—each farm and each crossroad community. Today massive and coördinated industry is the key to national prosperity and to employment.

War has opened our eyes to the basic importance of production, of industrial production especially. In the time of war, tangible results in the production of planes, guns, tanks, clothing, and foodstuffs, are demanded. Profit making is pushed into the background. Technological, instead of financial, requirements are emphasized. The engineer and the trained administrative official, instead of the financier and the politician, are the key men. As a return to peace time is attempted, output, rather than restriction of output, production, rather than profits because of restriction, must be emphasized if high standards of living are to be attained and unemployment eliminated. Capacity performance is needed in peace time, as well as in war time.

As a consequence of the historical background of the American people, our institutions and our ideas of prestige and of power find their roots in the soil of agriculture and of marketing, in the rural districts and the financial organizations, rather than in the factory and the industrial city. The western world is in the painful process

of shifting from one set of foundations to another. Production, rather than monetary considerations, is uppermost during this war and may be expected to continue in this position. Restriction of output in the interest of immediate individual or group gain, is now more clearly seen to be inimical to the general public than was the case a generation ago.

In the near future the engineering and efficiency expert may become more than the hired servant of financial interests. The production expert, when not contaminated by the notion of financial expediency, agrees that our productive equipment should be operated at capacity; that is, at maximum efficiency, in order to produce a large quantity of goods and services for the consuming public.

Engineering experts may be expected to take a leading or directing position in increasing national output. Their power derived from expertness and ability to serve the community, rather than ownership, may become "legitimate." If not, the calm student of economic and political problems anticipates a considerable increase in governmental control of industry.

A new era is indeed in the offing. The world is a vast moving panorama. Everything is dynamic. Nothing is static. The ideals and needs of today differ from those of yesterday, and those of today may not be desirable tomorrow. Science and engineering have been revolutionary agents in recent decades; they have given the western world a new industrial set-up in less than two generations. Productive capacity has advanced faster than political, economic, and social institutions have changed. In the United States we have a new technology functioning in a political structure provided with antique mental furniture. We need a new educational discipline. Americans should plan to fit their future political and economic systems into the molds made by science and engineering, instead of futilely attempting to fit science and engineering into the slowly modifying forms of the traditional political and economic systems. No nation with abundant manpower, resources, and scientific attainments, need undergo a serious depression.

In these days of rapid transportation, instantaneous communication, world markets, and the great use of natural power, prosperity and peace in one corner of the globe depend in no small measure on prosperity and peace elsewhere in the world. Nationalism is being outmoded by science exactly as localism has been outmoded by the auto, the telephone, and the radio. Instead of seeking negatively to protect ourselves against the low standards of living endured by workers in other parts of the globe, we should strive to raise the standards of living and of wages in those places by improving markets and facilitating the free exchange of goods.

A war economy does not allow mass unemployment. If unemployment can be reduced to a small amount in war time, why not also in peace time? After the war ends, the United States can afford a large Federal debt, provided the national output is maintained at a high level. The United States should plan for large production after the war —a $125 billion national income instead of the $70 billion income or less of the '30's.

A full-capacity wartime economy may be translated into a full-capacity peacetime economy; but it cannot be accomplished in a complicated technological society by enlightened, but

undirected, selfishness. In the words of another "the individual is accustomed to take expert advice in comparatively simple matters pertaining to health, repair of machinery, investment, construction of houses, education, and the like." Surely the average citizen cannot be expected to know the answers required for smoothing out the business cycle, eliminating mass unemployment, and for determining the desirable scope of governmental functions in the complex post-war economy. Perhaps no individual or group of individuals can do so; but trained men with adaptable brain power are most likely to know the answers.

If the American people, living in this world of rapid change, insist upon attempting to freeze capitalism and democracy in the pattern of 1900, or even of the 1920's, an explosion may be anticipated which would engulf both capitalism and democracy for a generation or more. Democracy and capitalism cannot hope long to continue to exist in a technological era of peace and great potential productivity if chronic large-scale unemployment and poverty for a third of the population follow the silencing of the guns in Europe and Asia.

The bold, persistent, and trained men of initiative will have new factors to subdue in the second half of the twentieth century. The struggle will be to banish war, mass unemployment, abject poverty, intolerance, and crime. The pioneers in the complex post-war era must be broadly trained men who are not encumbered with too much traditional lore—men who do not cease to grow mentally outside their special field on the day of college graduation. Education generally, and the education of engineers specifically, should aim to develop problem-solvers. Teachers in engineering colleges should assist the men in their classes not only to understand the new technology, but also to gain a vision of the new economic and social organization which science and engineering are forcing upon a reluctant world. Trained leadership in these days of bewildering transformations must possess the ability to meet new and unforeseen situations. Education is not something which stops with the Commencement ceremonies. If it does for a particular individual, that person is soon far behind the rapid march of events; he is mentally looking toward the setting sun.

Americans know how to organize production for war. The two years which have elapsed since Pearl Harbor offer clear proof of this statement. In December, 1943, the Federal Reserve Board index of industrial productivity stood at 245, while in the last of the '30's it stood at 100. Americans should be able to apply the same ingenuity and skill for peace purposes, for construction, for security, for comfort.

The brain power which has produced an automobile plant in which a multitude of carefully machined parts are brought together, placed on an assembly line and at the farther end of the line you see an automobile taking shape—presently gasoline is poured into the tank and a driver placed behind the wheel and the car drives away—the brain power which has produced such a plant, a giant rolling mill, the Golden Gate Bridge, or the Grand Coulee Dam, surely is able, if properly directed and motivated, to produce an industrial system which will end unemployment and give capacity production without the occasional chills of depression. Let us remember that depressions are man-made; they are not automatic or inevitable.

Of course, comforts and gadgets are not all there is to the good American life; but they are not to be scorned. As we increase national and world outputs and raise standards of living, the working week or year may be shortened, more stress may be placed upon leisure, upon wholesome recreation, upon art, upon music—in short, upon the arts of living. But we must first end war and the danger of war.

If the engineer is to play an important role in the post-war world, if he is to be an influence for progress in this critical period in world history, he must be trained in the humanities as well as in the sciences. He must learn to look upon the United States and ultimately upon the world as a big plantation or huge factory to produce food, shelter, clothing, and comforts, for the 136,000,000 Americans or for the 2,000,000,000 plus inhabitants of the globe. He must have a long-range view and a broad-gaged outlook. He must be able to look beyond the immediate in time and beyond the local in space. The engineer should be interested in directing the course of events in an expanding technological age.

The young engineer and the young scientist should be given a vision of a world of peace and plenty consequent upon the canalizing of forces in the realm of human relations, upon the application of the principles of science to the field of personnel relations in industry and in public administrative functions.

The expert is not to become a dictator; but when the world decides that peace and increased production are our goals, only experts—students of science, exact and social—can draw the blueprints and specifications necessary to achieve these shining goals. Popular vote may decide that the Golden Gate Bridge, or the Main Street Bridge in Cleveland, should be built, but only experts can determine the location and type of structure to meet the requirements of safety and economy. Engineers are not afraid of planning in their narrow field to meet a situation. We should not fear the application of science in the field of human relations after the goal has been broadly outlined.

Engineers and scientists understand the scientific approach to intricate problems. We need, in schools of applied science, to help in utilizing the scientific approach, instead of depending largely upon the emotional approach, to the broad problems of human relations. The emotional approach may be of value in determining the goal but not in building the road or roads to that goal. Many of the forces acting in the relations of man to man are less tangible or less easily isolated, but are just as potent and compelling as those studied in physics and chemistry.

Aeronautical Engineering Curricula and Its Relation to Present and Future Needs of the Industry*

By E. S. KAVANAUGH
University of Notre Dame

After working in the engineering field for a number of months many graduates from established engineering colleges ask themselves the question, "Has it been worthwhile to spend four years in college?" and all too often they do not answer with a definite "yes." Generally when the question is asked again a year or two later the answer changes to "yes," but it seems that the necessary adjustments the student has to make in changing from college to industry are still more numerous than is allowable. This question is not one that is restricted to graduates of the average college, as might be presumed, but applies as well to many graduates of technical schools, although probably to a smaller degree. Undoubtedly there are exceptions to this statement.

For several years now this problem has been under discussion at many engineering meetings and a solution to it may be forthcoming but such is not apparent at the present time. The various engineering schools are offering courses that are covering the same ground, at least a survey of school bulletins so indicates, and are evidently in agreement as to the basic material with which graduate aeronautical engineers should be familiar. The principal difficulty appears to be in the amount of material actually covered and the method of presentation of this matter, the latter undoubtedly affecting the amount of material covered. If, the amount of material stated in school bulletins as being offered for a particular course was actually covered, graduate engineers would undoubtedly be real engineers but such is generally not the case, as the bulletins are usually very ambitious.

A five year course is offered by some schools as the solution to the problem, but proper revision of the four year course should produce the desired results. It is quite generally agreed that the first two years of the aeronautical engineering training should be basically the same as taught to other engineering students. The first two years are usually taken up in training the students in the fundamentals of engineering with a few essential non-technical subjects such as English and Economics, to give the student a broader viewpoint of life in general. One drawback to the present system is that the instructors in the basic subjects do not rearrange their courses to fit into the ever changing engineering picture. It seems that the popular opinion in this country believes that our methods of teaching change with the times, but

* Presented at the 50th Anniversary Meeting, S. P. E. E. (Aeronautical), Chicago, Ill., June 18–20, 1943.

this opinion has been soundly disproved by numerous surveys. This criticism is not meant for the teachers of fundamental courses only as it applies as well to many technical instructors, but these fundamentals have been taught probably the same way for such a long period of time that it is much easier to follow the old outlines than it is to revamp the course. Naturally the fundamentals are still the same but the applications as brought out in class could be revised, particularly from the standpoint of aeronautical engineering, as most of the instructors do not really appreciate the applications to aeronautics.

Such subjects as physics and drawing could be taught easily from the aeronautical viewpoint in the larger colleges where the enrollment would allow separate sections for the various engineering departments, and, in the smaller schools the aeronautical applications could be given their rightful space in the course, if the instructor would investigate the possibilities. It is granted that the work necessary to revise all fundamental courses so as to make them apply equally to all engineering departments would be quite heavy and tiresome, but it is something that should be attempted.

The second year usually includes the study of descriptive geometry, a course that plays a vital part in aircraft engineering and one that is usually not fully understood by the student. The aircraft industry is making complete use of lofting technique at the present date and if the descriptive geometry course could be revised to include a study of lofting procedures, using models and manufacturer's methods, the application of descriptive geometry could be explained much easier and probably quicker than through use of such methods as the study of simple mechanisms, tracing paths of points and the like. The lofting procedures, once mastered, generally help the student to visualize other problems of a similar nature.

Another course that should be revised or dropped from aeronautical engineering is plane surveying, as usually taught. This course generally is given by civil engineering instructors, who, either do not see the aeronautical applications or do not have the time to make such applications and the course generally consists of the same material that the civil engineering student receives. The use of surveying instruments could be included in another course such as airport design or airline operations and the aeronautical student then could obtain a few more beneficial details of his chosen field.

Too often the aircraft structures course is merely a review of strength of materials or mechanics, principally due to the fact that most students do not obtain a working knowledge of the various types of problems. Here also it is evident that the applications of the equations used in strength of materials and mechanics are not grasped easily by the student although the method for putting this information across is not so evident. If the strength of materials and mechanics courses could be taught more thoroughly, more advanced work could be taken in the aircraft structures courses, at least touching on the fundamentals of such structural problems that are now being relegated to graduate work or omitted and left for the industries to teach. Perhaps this is trying to crowd too much into the strength of materials and mechanics courses but there does not seem to be the need for so much

repetition in the so-called structures courses. At the present time quite a lot of emphasis still is placed on the graphical solution of many problems whereas in industry similar types of problems generally are solved mathematically. It is probably well to know the graphical solution of certain types of problems such as beam-columns, but much of the time now spent in learning graphical solutions might be spent, more preferably, on giving the student a better understanding of the solution of monocoque structures, and other solutions which are known now only very well in the industrial stress departments. The colleges would do well to keep in closer contact with the different engineering companies and try to keep up-to-date with their new developments. In fact, a survey of the various aeronautical companies might be in order so that the colleges could obtain a better and more thorough understanding of industrial needs. New aeronautical textbooks are constantly being introduced but the field is progressing so rapidly that they cannot help but be obsolete. By contacting industrial engineering departments new ideas can be introduced to the student without waiting for a new text to be published. These departments are constantly developing short cuts which can be put to practical use much more readily than some very tedious integration that requires an expert to integrate, let alone to set up.

The high cost of flying, at the present time, prohibits many schools from offering instructive courses in flight. After the war though such costs, undoubtedly, will go down to the point where the colleges can afford to give the students a few hours of actual flight. A good student can become an aeronautical engineer without ever being in an airplane but he can never really appreciate many phases of aeronautics unless he actually experiences them. There are some schools at the present that offer flight courses along with their regular curriculum and other schools should follow their lead. Many theoretical explanations could be clarified with a few flights, such as, the effect of flaps, stalls, and spins. If the danger in flying is considered a drawback, why not make use of a Link trainer to instruct students. If a cost is still prohibitive the use of a wooden mock-up will still serve to a good advantage.

The airplane design course is probably the most popular course in the aeronautical engineering curricula and if other courses could hold the student's interest as thoroughly as this course does, the instructor's problems would be greatly diminished. The student evidently feels that this course is a really practical one and believes he actually is accomplishing something when he undertakes the design, although if he started to build his design he, undoubtedly, would learn otherwise. Such practical applications should be used whenever possible.

In considering methods of presentation, visual education should not be overlooked. Many fine pictures are being produced that can be fitted into engineering curricula, particularly the aeronautical subjects. By proper choice of film, some courses could cover nearly twice the material now covered and the subject could be gone over more thoroughly than it is possible to do by lecture or sketches. For instance, take the internal combustion engine course, most schools cannot afford the equipment necessary for viewing the actual combustion chamber of

an engine, while a picture of a chamber under operating conditions can be rented for a nominal fee; or, the carburetor, a rather complicated mechanism, can be explained more thoroughly through the use of sectional pictures or motion pictures. The student will be able to visualize an object better if a picture is used for illustration instead of a detailed verbal description. Probably the objection will be raised that many of these films are too commercial or that they do not stay on one phase of engineering for a long enough period of time; but, for example, just a few pictures showing where an airplane wing should stall, will stay with the student much more readily than the instructor's statement that the wing should stall inboard first. The old adage "One picture is worth ten thousand words," still holds true, no doubt, to a greater extent in our very technical field than in many others. By showing pictures the common practice that many instructors have of becoming too theoretical can be curbed and the more practical applications of theory can be visualized. Descriptions of machines and processes should not be overlooked as they serve to keep the student's interest in the course alive.

One teaching fault that apparently hits all teachers is the one that leads a teacher to change his course merely because he learns more about his subject, and not because he finds the students are not understanding his explanation. It seems the more experience the teacher obtains the more he expects the new student to know and, after a few years of teaching, he wonders, "Why are these new students so much dumber than last year's?" The instructor seems to forget that during the first year of teaching he, himself, had some difficulty in understanding all the things he told his students.

The future aeronautical student should have more knowledge of aeronautical subjects when he enters college as many high schools now are offering primary courses in aviation. Of course, this may result in a poorer student if these high school courses are taught improperly but, with proper instruction such high school graduates should make better aeronautical engineers and allow the colleges to strengthen their courses. It is hoped that more success will be had with the aeronautical courses than has been had with many high school physics courses. Otherwise, the college instructor may find that he has to correct the student's prior education before he can start his college course properly.

Too many hard and fast rules live in schools, many of them devised to lessen the instructor's work and others made to serve a very good purpose but badly used after the original thought behind the rule has been lost. For instance, a rule of which nearly everyone has heard is "Never scale a blueprint." Such a rule is fine, if used in its proper place but many an airplane would never get off the designer's sketch pad if prints were not scaled. Still graduate engineers have lost their jobs merely because such a rule was pounded into them until they applied it everywhere.

There is great need for the use of more thought in the presentation of the material covered by our present day aeronautical engineering curricula rather than attempting to change the courses now offered to something more specialized, or for that matter, to generalize them to the extent where the graduate is a general engineer rather than an aeronautical engineer.

Post-War Academic Problems*

By F. L. PARTLO

Associate Professor of Mathematics and Physics
Coördinator War Training Programs
Michigan College of Mining and Technology

I have been asked to discuss our present instructional problems and their relationship to post-war education. The assignment implies that we now have instructional problems and that, in the future, there will be post-war education. I might say that I am emphatically of the opinion that we have the problems and that there will be post-war education. Many of our problems have nothing to do with the war. They are pre-war problems that have not been solved, possibly not recognized as problems.

As for post-war education, there are those who believe that the college's experience in streamlined teaching of courses is going to have a profound effect upon curricula. I cannot bring myself to concur in this opinion. As I see it, engineering education is likely to be influenced in quite a different respect by our war experience.

The war is having one universally recognized, outstanding effect upon our way of life—in the nature of a shrinking of this globe of ours, when measured in terms of hours of travel time from place to place. A few years ago, the circumference of this globe, measured in terms of travel time, was, at best, some weeks. Now we can measure it in days. The change is enormous, and relates to engineering education in one very vital way. It is no longer the consensus that we can live an isolated life within the boundaries of Canada on the north, Mexico and the Gulf of Mexico on the south, the Pacific Ocean on the west, and the Atlantic Ocean on the east. Our nation is forced, whether we like it or not, to be a citizen of the World of Nations. Our engineers are citizens of this nation, and, in turn, are World Citizens. This profound change needs to be kept in mind in designing the engineering curricula of the future.

Moreover, it intensifies a problem of long standing. In discussing curricula and post-war potentialities, one is quickly confronted by the much discussed and yet unanswered questions, "What is an educated engineer?" and "What is the objective of an engineering curriculum?" The pages of the *Proceedings of the Society for the Promotion of Engineering Education* from the date of its inception are literally filled with discussions of these questions. They haven't yet been answered, and I do not think that they ever should be finally answered. The ideal curriculum and the ideal education of an engineer are, and properly

* Presented at the Michigan College of Mining and Technology S.P.E.E. Branch Meeting, January 20, 1944.

should be, continually in a state of flux. However, before we can ever hope to agree on what we would consider ideal curricula for this college, it seems to me necessary that we state specifically and precisely just what the purpose is to be in the training that we are offering. It seems to me that the first thing that we need to do is to agree upon a statement of our objective. Until we do that we are in no position to intelligently add to or subtract from our various engineering curricula.

In June, 1939, there was appointed a special committee of the S.P.E.E. to prepare a report on the Aims and Scope of Engineering Curricula. I wish to commend for your careful study both the report, appearing in Vol. XLVII of the *Proceedings,* and a round table discussion on the Aims and Scope of Engineering Curricula in Vol. XLVIII of the *Proceedings,* published under dates of March and December, 1940. This report represents opinions which were reasonably concurred in by the twelve members of the Committee, all outstanding engineering educators. Second to a statement of our objectives, I would place a critical and detailed analysis of our various engineering curricula in the light of the report of this Committee on the Aims and Scope of Engineering Curricula.

Since the objective is likely to change, and since the ideal curricula, assuming there be such, are bound to change, this statement and analysis should be repeated at frequent intervals. Having once stated our purpose and analyzed our curricula, we cannot sit back and say, "There, that job is done!" It is never done! Conditions change our problems. Our solutions must necessarily change. In this connection, my statement concerning the world-citizenship nature of the engineering graduates of the future has a direct bearing. This represents one of the contemporary changes in the necessary specifications of an ideal curriculum. More than ever before it is now necessary that an educated man be well informed in economic and political history and geography, that he have an understanding of the development of our American form of government and the reasons for it. We have an obligation to our students to teach them these things. Perhaps, you will say, "They teach that in high school." But do they? We might properly ask the questions, "Should they teach these things in high school?" It may well be that experience and maturity beyond those of high-school students are necessary for a proper comprehension of historical and economic facts.

Another matter deserves serious consideration. You have all confronted the situation in classrooms, laboratories, and written reports. For a description of it I quote P. W. Swain, editor of *Power* magazine:

> "From long observation of engineers, I would make the following comments:
> 1. More than any other one thing, the ability to use the English language distinguishes the successful engineer from the unsuccessful.
> 2. In general, engineering writing is unnecessarily stiff, involved, and long-winded."

I submit this one quotation. It is typical. It clearly states the problem. Before we put our stamp of approval upon a man and say that he is a Michigan Tech engineer, he should be in a position to use effectively the English language in both oral and written form.

Surveys indicate a considerable tendency to introduce more and more technical courses in engineering curricula.

For the last ten or fifteen years many a college has added course after course, with seldom a deletion. We hear, over and over again, "They should have a course in this" or "They should have a course in that." We find ourselves confronted by the dilemma that students should study more and more subjects in the same length of time. The engineering curricula have for decades been notoriously filled with difficult subjects. It is not feasible to introduce more. The only way that any individual student can take the proposed new courses is not to take something else. This obviously is leading to the condition wherein we will be offering a multitude of courses with relatively few students in the sections. It is not economical and I do not believe it is justifiable to teach with four, five, or six students in a section.

Before we offer more courses for the students to take, we should find time in which they are to take them. There occur to me at least five possible procedures, one or more of which might provide some of this additional time. I wish to consider them in some detail.

First, the deletion of irrelevant courses. I have no particular course in mind; however, the matter should be carefully considered in connection with each course offered. In this category are courses which properly belong in a graduate program of study. If there be such, they should be eliminated without hesitation.

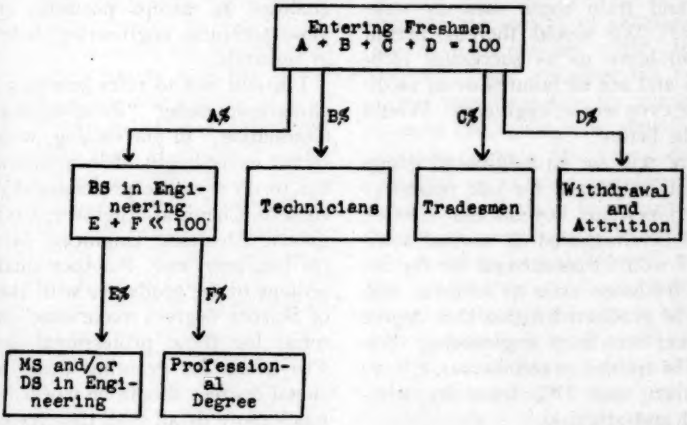
Second, the deletion of irrelevant material in existing courses. I doubt not that many of our courses contain material which does not properly belong in them. If this be so, they should be pruned mercilessly. Again, by irrelevant material I mean, among other things, subject-matter which properly belongs in a graduate course. Surveys indicate that there is a strong tendency to "give them the dope" and to pack into courses subject-matter which could more properly and more effectively be studied in a graduate course.

Third, the elimination of duplication. I have in mind here two types of duplication. One is the more obvious type, where substantially the same course is taught in more than one department or even within a department. We have some instances of duplication in our catalog, and they could, in all probability, be eliminated without serious harm to our program as a whole. The other, and less obvious sort of duplication, commonly referred to as review, should be examined critically. A certain amount of review frequently is necessary; but there is a serious danger of its being overdone, and this should be avoided.

Fourth, increase in the tempo of existing courses. We have an example of this carried to the extreme in our war-inspired training programs. The college educator is prone to say, in connection with these concentrated courses, "It can't be done." I would urge that judgment in this matter be deferred until experience provides a basis for a valid opinion. I am not in a position to say that it can or cannot be done. In all probability, the eliminations in such a high-speed concentrated course would be higher. It is my belief that they should be higher. Is it not true that many men the country over bear the stamp of approval of a Bachelor of Science degree in engineering who never progress beyond the stage of technicians?

Fifth, lengthening of the training period. This, of course, is a much discussed subject. I find myself inclined to look with disfavor upon it. It is

FLOW SHEET
OF
PROPOSED DISPOSITION OF ENTERING FRESHMEN



intimately related to the next phase of the subject which I wish to consider.

Permit me to call to your attention a problem of long standing, wherein we have an obligation about which we have done nothing in the past. Of the students in any normal entering freshman class, relatively few are eventually graduated. This untouched problem has to do with those who are not graduated. Most of these men are not without ability. We have a social obligation to discover those abilities and train the men along those lines. I say we have a social obligation and I say it advisedly. The man who leaves a college with his three or four failures, leaves as a failure. He has been marked as such. We have sent him out a failure. Most of those men will go the rest of their lives influenced by the fact that they have left college as failures. Having accepted them as students, we are not fulfilling our obligations to society when we permit them to leave marked as failures and do nothing about it. We at the Michigan College of Mining and Technology have a particular obligation in view of the fact that this college is financed from public funds.

A certain percentage of the men whom we do not graduate, and who leave as failures, would make good tradesmen. Would it not be better to recognize that fact early in their training, train them as tradesmen, and let them leave us, not as failures but as successes? I know perfectly well that some of you will look upon this with horror, that you will say, "We're not operating a trade school. Let somebody else do that!" But in "letting George do it" we are failing to meet our obligations to these men and to society. I believe it is more important to meet our obligations than it is to "let George do it."

And then there is another percentage of the men whom we never gradu-

ate, and some whom we do, who would make good technicians. Why not set up and operate a Technological Institute paralleling our engineering program and train these men as technicians? We would thereby permit them to leave us as successful technicians and not as failures or as mediocre, or even worse, engineers. Would it not be better?

There will be an additional group who will withdraw, for one reason or another, perhaps beyond our control, or will be eliminated by normal attrition. I would thus account for the entering freshman class as follows: A% would be graduated with a B.S. degree in some branch of engineering, B% would be trained as technicians, C% as tradesmen, and D% leave by withdrawal and attrition.

Let us consider further that group upon whom the degree of B.S. in some branch of engineering is conferred. As I intimated a moment ago, it is my opinion that we have too much specialization at the undergraduate level; that some of this specialization should be left to graduate work. Is it not your experience in these specialized courses that the general run of candidates for the B.S. degree constitute a drag on your class, and that you would like to do a much higher level of work? I am confident that your deliberate answer to that question would be "yes." Those courses should not be in a curriculum leading to the Bachelor of Science degree, but more properly belong in a graduate course of study. A small proportion of the men who are graduated with a B.S. in engineering could profitably continue their studies in curricula leading to a master's degree or to a doctorate in engineering. Such able men should be encouraged to continue their studies beyond the bachelor's degree, and provisions should be made, if necessary, to assist in financing that additional training. These graduates would then be qualified to accept positions in the more technical engineering fields and in research.

I would like to refer you to a short paragraph under "Requirements for Graduation," in our catalog, which receives exceedingly little attention. It has to do with the professional degree such as Chemical Engineer, Civil Engineer, Electrical Engineer, Mechanical Engineer, etc. Another small percentage of the graduates with Bachelor of Science degrees make excellent material for these professional degrees. Provisions for granting these professional degrees should be worked out in much more detail than they have heretofore been, and the likely graduates in each succeeding class should be contacted after four or five years of professional experience as engineers with a view to encouraging them to become candidates for professional degrees. Few, if any, are going to do this of their own accord. It is up to us to follow up. That we could and should do.

To assist you in visualizing this division of the entering freshman class, as I have proposed in this outline, I have prepared a Flow Sheet summarizing the operation. I give this to you in all humbleness for your consideration and discussion.

Perhaps you would ask me, "How are you going to know who should become a tradesman, a technician, a candidate for a B.S. degree in engineering, etc.?" In anticipation of that question, I would like now to present my answer to it.

I am sure that many of you are familiar with the pioneer work that has been done by the Engineers' Council

for Professional Development in the field of the selection of students for the engineering profession; the initial work along this line was sufficiently successful to justify the Carnegie Foundation for the Advancement of Teaching in assisting in financing the project in the field of measurement and selection of students, under the sponsorship of S.P.E.E. and E.C.P.D. This study contemplates tests at entrance and at the end of each academic year. Eleven institutions have been selected for the initial tests, and to date tests have been given in five of these eleven institutions. I would recommend and strongly urge that this college participate in that program at the earliest possible opportunity. The information obtainable from these tests could serve as a framework around which the program of testing could be built, and upon which the selection of men to enter the tradesman's class, the technician's class, and the class of candidates for B.S. degrees could be made. This would involve the employment of a student personnel director, whose duties would include the preparation and administration of examinations and the analysis of the results therefrom. On the basis of this information, together with all other possible sources of information such as interviews, etc., recommendations could be made for men to enter the tradesman, technician, and B.S. candidate classes.

In conclusion let me restate the six main items: *First,* we should clearly state our objective; *second,* analyze our curricula, giving particular attention to course sequences, the introduction of economic and political history and geography, the introduction of additional improved courses in English, and the elimination of excessive packing of the curricula with specialized courses; *third,* consider the possibilities of providing time for needed additions to the curricula by deletion of irrelevant courses, deletion of irrelevant material in existing courses, elimination of duplication by increasing the tempo of courses, and lengthening of the training period; *fourth,* consider the proposal to discharge more equitably our entering students as Bachelors of Science in engineering, or technicians, or tradesmen; *fifth,* further the promotion of graduate and professional degrees; and *sixth,* participate in the Measurement and Selection of Students study of the Carnegie Foundation for the Advancement of Teaching, and set up a Student Personnel Directorship to prepare and administer selection and progress examinations and to accumulate and make use of personnel information relative to the students.

I lay no claim to completeness in this outline of problems. It may be that I have failed to mention some which transcend in importance those that I have treated. In any event, my sincere hope is that we may recognize when changes should be made and then make them to the ultimate improvement of our overall program.

Engineering Teaching

By RUTH McG. LANE
Vail Librarian, Massachusetts Institute of Technology

A Reading List

selected to show trends in the development and practices of engineering education. The references starred may be of particular value to those young engineers who have suddenly been given the responsibility of teaching under wartime conditions. The list as a whole should help in planning for post-war changes. A slight emphasis on electrical engineering is due to the compiler's greater familiarity with that field.

Introduction

The successful engineering teacher knows basic educational theory, the psychology of the learning process, and the principles of teaching. He adapts general educational principles to the special needs of engineering. In addition he is familiar with the history and development of engineering education, reads about the experience and advice of prominent engineering educators, and follows current trends in engineering teaching practices. All this can be accomplished most satisfactorily through reading, writing, and discussion.

Each professional engineering society has its committee on education, sponsors discussions, and publishes occasional educational articles, but the Society for the Promotion of Engineering Education, through its Journal of Engineering Education, is the clearing house for such information. The majority of references in the following list of reading suggestions therefore are from that source. To simplify the use of the list references are grouped under five heads:

I. Development of engineering education.
II. Objectives of engineering education.
III. Curriculum: courses, subject content, etc.
IV. Teaching methods.
V. Special problems of engineering teaching.

I and II concern the philosophy of engineering education which is more or less constant. III and IV concern the practice of engineering teaching which is based on fundamental principles but varies with current demand. Greatest emphasis has been placed on IV: Teaching, methods, as of immediate practical importance.

Abbreviations used:

A.I.E.E. Trans. .....*American Institute of Electrical Engineers Transactions*
E.E. .....*Electrical Engineering*
I.E.E.J. .....*Institution of Electrical Engineers Journal*
J. Eng. Ed. .....*Journal of Engineering Education*
M.E. .....*Mechanical Engineering*
S.M.P.E.J. .....*Society of Motion Picture Engineers Journal*

I. *Development of Engineering Education*

A brief survey as given in outstanding reports, investigations, and summaries.

Mann, Charles R. Study of engineering education. Prepared for the Joint Committee on Engineering Education of the national engineering societies. Carnegie Foundation for Advancement of Teaching Bulletin 11, 1918.

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*Hammond, H. P. Promotion of engineering education in the past 40 years. *J. Eng. Ed.*, **23**: 11: 44–61, Sept. 1933.

Rees, R. I. Professional development of the engineer. *A.I.E.E. Trans.*, **52**: 388–90, June 1933. (Engineers' Council for Professional Development and engineering education.)

*Engineers' Council for Professional Development, Committee on Engineering Schools. Present status and trends of engineering education in U. S. Report prepared by D. C. Jackson. (Survey of 136 institutions made during 1935–1938.) 1939.

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Engineering defense training. R. A. Seaton (Director, Engineering Defense Training, U. S. Office of Education), A. A. Potter (Chairman, E.D.T. Advisory Committee, U. S. Office of Education), G. W. Case (Principal Specialist, E.D.T., U. S. Office of Education). *J. Eng. Ed.*, **32**: 30–56, Sept. 1941.

Ocvirk, F. W. ESMWT—an experiment in engineering education. *J. Eng. Ed.*, **33**: 463–9, Jan. 1943.

Case, G. W. Engineering colleges' contribution to ESMWT. *J. Eng. Ed.*, **33**: 479–81, Mar. 1943.

Activities in current ESMWT program. *J. Eng. Ed.*, **33**: 580–87, Apr. 1943.

Heald, H. T. Recent developments in Army and Navy college training programs. *J. Eng. Ed.*, **33**: 496–50, Mar. 1943.

Armsby, H. H. Critical analysis of ESMWT courses. *J. Eng. Ed.*, **34**: 257–66, Nov. 1943.

The following four articles give British points of view on similar developments.

Institution of Electrical Engineers. General discussion on electrical engineering education. *I.E.E.J.*, **84**: 161–86, Feb. 1939.

*Fleming, A. P. M. Critical review of education and training for engineers. *I.E.E.J.*, **89**: 1: 376–88, Sept. 1942. Discussion pp. 388–435.

Institution of Electrical Engineers. Post-war planning committee: Educational Subcommittee. Report: Education and training for engineers. *I.E.E.J.*, **90**: 1: 223–33, June 1943.

Jackson, Willis. University education and industrial training of engineers, with particular reference to telecommunications. *I.E.E.J.*, **90**: 3: 53–60, June 1943. Discussion pp. 61–72.

II. *Objectives of Engineering Education*

The aim of engineering education is to train young men to carry on the profession of engineering. Much engineering philosophy of a half century ago is still basic; current practice adapts it to changing conditions. Through years of practical experience engineers have formulated objectives and some of them have expressed their educational philosophy in writing. A few such papers by prominent engineering educators are listed below.

Scott, C. F. Best engineering education. Introduction to a digest of papers on engineering education in *A.I.E.E. Trans.* *A.I.E.E. Trans.*, **27**: 67–78, 1908.

Steinmetz, C. P. Electrical engineering education. *A.I.E.E. Trans.*, **27**: 79–85, 1908. Discussion pp. 86–135.

Doherty, R. E. Educational aspects of engineering and management. *A.I.E.E. Trans.* **51**: 848–57, Dec. 1932.

Educational preparation for creative technical engineering leadership. *J. Eng. Ed.*, **23**: 309–21, Jan. 1933.

Wickenden, W. E. Professional phase of the engineer's education. In "Investigation of engineering education" by S.P.E.E., vol. 2, pp. 1041–1117, 1934.

*Jackson, D. C. Objectives of engineering education. *J. Eng. Ed.*, **26**: 60–85, Sept. 1935.

Williams, C. C. New epoch in engineering education. *E.E.*, **55**: 132–6, 1936.

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Hessler, V. P. Statement of objectives for electrical engineering. *J. Eng. Ed.*, **32**: 542–7, Mar. 1942.

*Wickenden, W. E. Second mile. *E.E.*, **61**: 242–7, May 1942.

The second mile—a re-survey. 1944. Engineers Council for Professional Development.

*Finch, J. W. Post-war problems of engineering education. *J. Eng. Ed.*, **34**: 245–56, Nov. 1943.

III. *Curriculum: Courses, Subject Content, Etc.*

Because the curricula of engineering schools are subject to frequent change only a few fairly recent references are listed here as indicative of the type of information available.

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1. Individual traits
2. Laboratory instruction
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Mathematics in the Army Specialized Training Program

By JAMES H. ZANT

Professor and Acting Head,
Department of Mathematics,
Oklahoma A. & M. College

The content of the mathematics which was taught to men in the Army Specialized Training Program was given in very brief topical outline only, and may be found in several publications.* This was the only material furnished to the participating colleges. From this, the departments of mathematics had to build the courses to be taught. A comparison of the way the various colleges have met the situation would be interesting, but probably not possible just now. These remarks will be concerned with the problem as we have handled it here and some of the implications for the future of college mathematics in this country.

Colonel Beukema, Director, Army Specialized Training Division, has said, "As you know, the Army Specialized Training Program was launched by the War Department as a means to provide men who had been developed along specific lines needed by the Army. It was nothing more than this and nothing less." † He goes on to state that the procedure was to find from the Army groups their requirements in men and the training they needed. The courses to fit these demonstrated needs were prepared with the help of the American Council on Education by groups of civilian instructors, specialists in their various fields. These curricula were drafted quickly and then "submitted to the army services to determine whether or not they fitted the particular needs as the services saw them. Only minor adjustments were found to be necessary." ‡ Finally an advisory committee consisting of ten college presidents went over the curricula in detail and revisions based on their recommendations were made.

The men came from every branch of the service and their initial selection depended on making a satisfactory score on the Army General Classification Test. The minimum score for admission was 115. They were then processed and given screening tests through the S.T.A.R. Units which made every effort to see that the men were qualified to carry the work before they were finally assigned to an A.S.T.P. Unit.

* See JOURNAL OF ENGINEERING EDUCATION, Vol. 34, pp. 588–629, and *American Mathematical Monthly*, Vol. L, pp. 469–470.

† Col. Herman Beukema: "Current Status of the Army Specialized Training Program," THE JOURNAL OF ENGINEERING EDUCATION, Vol. 34, page 50.

‡ *Ibid.*, page 51.

A study of the curricula, sequence, time limits on courses, and the like, will indicate that this was a distinct departure from standard-before-the-war educational practice. It may well have far reaching effects on the future of college education. It was a program made in part by college teachers and administrators. However, that does not indicate that it had no faults. In fact the Army itself did not consider it satisfactory in its present stage. To quote from Col. Beukema once more: "I hope I am not going to leave with you the conclusion that I am fully satisfied with the program. I have not been so from the first moment that the plan was put before me some few days before I was ordered to Washington to take charge of it. It needs many changes and corrections. The corrections and the changes and improvements can come only as we work together to meet the problems developed in our practical experience."

"I say that because you will agree with me that we are developing a line of special training which cuts through every established line of the Army and every established line of education. We are in that sense innovators because war compels us to be so. We are doing what you in education have done since there first was education. We have to cut our teeth on these problems, discover where the errors are, and then, with your help, correct those errors in order to get the result that the War Department is asking for." *

Here at the Oklahoma A. & M. College we offered all of the A.S.T.P. mathematics courses. These include Mathematics: AST–406, Algebra and Trigonometry—72 hours of instruction; AST–407, Analytic Geometry—60 hours of instruction; Mathematics: AST–408, Differential Calculus—60 hours of instruction; Mathematics: AST–401, Integral Calculus—60 hours of instruction. The A.S.T. Program was set up in the Division of Engineering, but the mathematics courses were organized and administered by the Department of Mathematics which is located in the School of Arts and Sciences. The teachers, however, were drawn from many sources. A small per cent of them were regular mathematics professors but more were professors from the Division of Engineering and a few were from other departments of the college.

Under these circumstances and for other reasons we felt it was necessary to insist on much more uniformity in teaching outlines, tests, etc., than in the ordinary mathematics classes. Lessons were carefully outlined for the whole term and teachers were expected to cover the same work each day. The same test was given to the whole group in a body when possible. The majority of these tests were machine graded and distributions and percentiles were worked out on the group as a whole, and on each section. This enabled each teacher to see how his sections were performing in comparison with the other sections and with the group as a whole.

The questions on these tests were of the multiple choice variety in which a problem is stated and followed by four or five answers, one of which is the correct one. The student had to solve the problem in order to choose the correct answer. This sort of test has some disadvantages which we recognize, but it does make it possible to cover much more ground than other sorts of tests. It was common for the

* Col. Beukema, *op. cit.*, pages 60–61.

group to take a test of twenty questions and have five or six per cent finish the test in 30 minutes with a perfect score. It had an added advantage to the students of this program. The test which the Army sent in at the end of the tenth week was made up entirely of this sort of questions.

We had no way of comparing these students with those from other units or with regular college students. These comparisons will be possible a little later on and should be very interesting. I am convinced from a good many years' experience with college mathematics students that in many ways they did better work than civilian students. They were, of course, a better selected group than many of the large state institutions had before the war. Judging from tests we gave, they had a better mathematical background and their habits and times of study are certainly different from those of peace time students.

Implications.—Some of the implications of this and other wartime programs may be helpful and thought provoking. Mathematics departments in many of our colleges do not have much time for the much discussed post-war planning. We are too busy trying to carry on the war programs and make the curricula which have been handed to us as serviceable to the various branches of the armed forces as possible. However, this very experience should be of great help to us when the emergency is over and the time comes to reorganize and start over again. Even though we are rushed and busy, we should not fail to be thinking about some of the changes that are in store for us. To my mind some of the implications of this whole experience for college teaching are:

1. These programs are going to have a definite influence on mathematical education, especially engineering mathematics. We should not make the mistake of thinking that we can go back to where we left off in December, 1941.

2. General education may well take a new emphasis. The basic phase of the A.S.T. Program is considered, by the Army at least, as general education. It contains mathematics, physics, chemistry, English, history, and for the first time in the history of many colleges, geography. This was not only basic to engineering but also to all other sorts of advanced training which the Army wants. In fact it was considered terminal for many of the students, that is, it was general education which fits the man for the job the army wants him to do.

3. Courses in mathematics, and also in other fields, will probably have to become more functional than they have been in the past. That is, they must be built to fit the needs of the students. These A.S.T. courses were not designed as complete courses in mathematics or physics or geography. They were designed to give the soldier what he needed to do his work. The same thing is happening in many other emergency courses, both those for the armed forces and those for industry. They teach the mathematics the students will need, often without meanings or other extras. This may not be what we want as post-war education, but it is likely to come and if mathematics is to hold the respect it has gained in the past few months it will have to adjust itself to the conditions it meets.

4. Mathematics will probably have to be taught more efficiently than it has been in the past. We have taught our graduating engineers and majors to do good work. But even at best, this has represented only a small per cent of the total who have come under our instruction.* We have probably expected too much of the average student who takes a course in mathematics. Or to be more realistic the majority of the students in our classes have been trying to take courses for which they are not fitted. This inefficiency, whether the fault of the schools of engineering or some one else, is not likely to be tolerated in post-war education.

This does not necessarily point to a dark future for mathematics. If we, as mathematics teachers, can realize that we are being called on to furnish some of the most important processes and skills of this new concept of education, and if we can look at each new situation which presents itself with the determination to serve the student's needs to the best of our ability, we should have little trouble in making the necessary adjustments to perform the task. In the past this subject has been one of the most important aids to the progress of civilization and there is no reason to think that the future holds for it any smaller position of responsibility.

* At the Oklahoma A. & M. College less than 10% of a Freshman Engineering class graduates four years later.

Sections and Branches

The annual meeting of the **Michigan Section** of the Society for the Promotion of Engineering Education was held Saturday, April 29th, at Ann Arbor, the University of Michigan being the host school this year. Some seventy-five engineering educators attended the afternoon session, and more than one hundred educators and their wives were present at the dinner meeting held in the Michigan Union.

Dean C. C. Winn, of the Detroit Institute of Technology, presided at the afternoon session held in the Rackham School for Graduate Studies. After Dean Lovell of the University of Michigan welcomed the group, Carl Wheaton of the War Manpower Commission presented a paper on "What the Engineering College Can Do in the War Effort, in the Closing Periods of the War, and Post-War Periods." Mr. Wheaton traced through the past and current efforts of the engineering colleges in their work training personnel for war production plants under the Engineering Science Management War Training program sponsored by the United States Government. He is certain that the demand for training personnel for specific assignments in industry will continue following the war. He also spent considerable time in discussing the problems involved in the education of the returning veteran.

Following Mr. Wheaton's address, L. M. Gram, Chairman of the Department of Civil Engineering at the University of Michigan, spoke on "Engineering—A Profession." In a well-ordered paper, both in preparation and presentation, Professor Gram outlined the status of the engineer and his work, and compared the medical, legal, theology and other professions with the profession of engineering. An interesting discussion followed the paper.

Dean Ivan C. Crawford, University of Michigan, and M. R. Graney, Purdue University, were the speakers at the evening meeting. Dean Crawford emphasized that the professional aspect in the student can be developed by the engineering teachers and the professional societies. He stated further that engineering educators should not necessarily lengthen the engineering curriculum but should attempt through counselling and other means to guide high school students contemplating the study of engineering to prepare themselves in the liberal courses while still in high school.

Dr. Graney in his paper—"Ideas Underlying the Technical Institute Concept, and How It Is Operating at Purdue University"—outlined the objectives, the problems, and the results of this type of technical training. Designed to train both the graduate and the non-graduate of high school for a specific job or position which lies between scientific work and the skilled crafts, the technical institute performs a function which is vital to industry in time of war and peace. It permits the individual to advance himself through the study for a particular job, rather than a general training for broad future work. Dr. Graney stated that the

technical institute is primarily designed for the student who has settled definitely in a particular line of work, and who wants training for a specific job. Purdue University's technical institute work is now under way in three industrial centers of Indiana. It is so arranged that a student may enroll for one, two or three years' work, although any one year is a complete course in itself, and leads to a certificate.

The following officers were elected to serve for 1944–45:

Chairman: C. A. Brown, General Motors Institute.
Vice-Chairman: T. C. Hanson, University of Detroit.
Secretary-Treasurer: W. J. Emmons, University of Michigan.
Member Nominating Committee: L. G. Miller, Michigan State College.

The Section accepted the invitation of the General Motors Institute of Technology to hold its 1945 meeting at the General Motors Institute at Flint.

Southeastern Section.—The Georgia School of Technology was host to the eleventh annual meeting of this Section held April 29, 1944. There were 89 members present representing 21 engineering colleges in the Southeast.

Dean F. L. Wilkinson, University of Louisville, Chairman of the Section, presided at the morning session. The Section was fortunate in having Dean H. P. Hammond as guest speaker. Dean Hammond, Chairman of the Committee, gave a preview of the report of the S.P.E.E. Committee on Engineering Education after the War.

Professor D. W. Dutton of the Georgia School of Technology presided at the luncheon meeting. The principal speaker was H. Carl Wolf, president of the Atlanta Gas, Light and Power Company. His theme was a closer cooperation between the Engineering Colleges and Industry after the war.

Dean L. L. Patterson, Mississippi State College, Vice-Chairman of the Section, presided at the afternoon session. The subject for discussion was, "What Can We Do to Implement the S.P.E.E. Committee Report and How May We Put Its Recommendations into Action?" The following men presented papers on the subject: Dean N. W. Dougherty of the University of Tennessee; Professor A. G. Holmes of Mississippi State College and Roy S. King of the Georgia School of Technology.

At the business session it was decided to formulate a research division within the section. Also the following officers were elected for the year: L. L. Patterson of Mississippi State College as Chairman, Joseph Weil of University of Florida as Vice-Chairman and H. Gale Haynes of The Citadel as Secretary. It was decided to hold the next annual meeting at Vanderbilt University.

H. GALE HAYNES,
Secretary.

College Notes

Purdue University.—At a meeting of the Board of Trustees it was voted to merge the Department of Applied Mechanics of Purdue University with the Civil Engineering. The new division will be called the School of Civil Engineering and Engineering Mechanics. This change is effective July 1, 1944. Professor Ralph B. Wiley who has been head of our School of Civil Engineering becomes head of the School of Civil Engineering and Engineering Mechanics.

Engineers' Council for Professional Development.—The yellow announcement of the new version, *The Second Mile—A Re-survey,* sent to members of S.P.E.E. late in March has brought 34 orders from Engineering Schools for 100 or more (two orders for 200 and two for 500); also four orders from industry (two for 100 and two for 300); also about 100 orders, half for small lots and half for single copies. Total (April 10) 5,800. (Sale of 16,000 in a year and a half made the original a "Best Seller." Of the Re-survey a third as many have been sold in half a month.)

"Will You Help?" in getting the pamphlet to those who need to know "in this world of rapid change and shifting emphasis on values" the fundamentals of a profession and Wickenden's answer to his new question "Does an engineer need his profession?"

As you "read and re-read" the revitalized message please consider who ought to have it and how to get it to them; students in college or leaving college; recent students and graduates, in industry, in service or elsewhere; older engineers. Maybe you know a personnel man or other key man in engineering or in industry who may be ready to aid in spreading the good word. True, things educational and professional are quite upset; hence fundamental principles may be more seriously received. Your Help, please, by action or by suggestion. Thank you—

CHAS. F. SCOTT, *Chairman,*
Committee on Professional Recognition.

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